Deep-sea Echinodermata of British Columbia, Canada

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DEEP-SEA ECHINODERMATA OF BRITISH COLUMBIA, CANADA

by

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Abstract

Lambert, P., and Boutillier, J. 2011. Deep-sea echinodermata of British Columbia, Canada. Can. Tech. Rep. Fish. Aquat. Sci. 2929: viii + 143p.

This document is the first in what is hoped to be a series of Fisheries and Oceans technical reports which will supplement other taxonomic literature and help researchers identify and collect information on the diversity, distribution and trends in abundance of marine invertebrates that are present in waters off British Columbia, Canada. This report focuses on the echinoderms which occur exclusively below a depth of 200 m off the coast of British Columbia. There are approximately 100 species described and figured in this report, including eight crinoids, 11 echinoids, 20 ophiuroids, 12 holothuroids and 52 asteroids. Included in these numbers are three new species of crinoid and two new species of asteroid. Species accounts include synonyms, diagnostic characters, type locality, material examined, known geographic range, new distributions, and other notes about biology or taxonomy.

Résumé

Lambert, P., and Boutillier, J. 2011. Deep-sea echinodermata of British Columbia, Canada. Can. Tech. Rep. Fish. Aquat. Sci. 2929: viii + 143p.

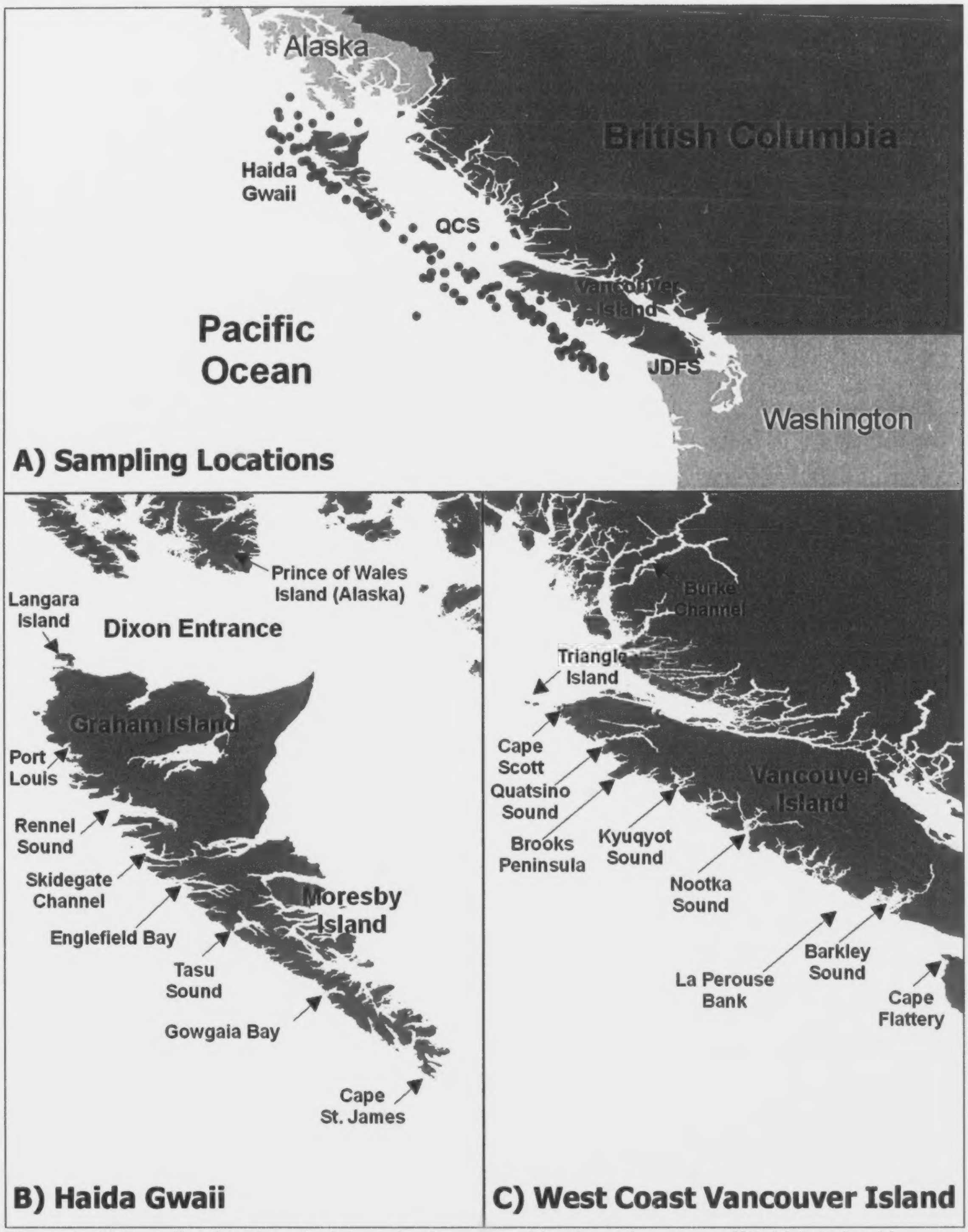
Le présent document n'est, on l'espère, que le premier d'une série de rapports techniques de Pêches et Océans. Ces rapports viendront s'ajouter à la littérature taxonomique existante et aideront les chercheurs à repérer et à recueillir des renseignements sur la diversité et la répartition des invertébrés marins vivant dans les eaux de la Colombie-Britannique, au Canada, ainsi que sur les tendances de leur abondance. Le présent rapport cible les échinodermes qui habitent exclusivement des profondeurs de plus de 200 m au large des côtes de la Colombie-Britannique. Une centaine d'espèces y sont décrites, dont huit crinoïdes, 11 échinoïdes, 20 ophiuroïdes, 12 holothuroïdes et 52 astéroïdes. Parmi elles figurent trois nouvelles espèces de crinoïdes et deux nouvelles espèces d'astéroïdes. Chaque description d'espèce présente les synonymes, les caractères diagnostiques, la localité type, le matériel examiné, l'aire de répartition géographique connue, les nouvelles répartitions et d'autres remarques sur la biologie ou la taxonomie.

Introduction

This technical report is the first in a series of planned documents that are intended to provide identification aids to biologists for documenting and assessing the status British Columbia's marine invertebrates. Knowing what animals we are working with is the key basic building block within an integrated science-based approach to managing aquatic resources and ecosystems, meeting two of the strategic outcomes outlined in *Science at Fisheries and Oceans Canada – A Framework for the Future*: 1) Healthy and productive aquatic ecosystem; and 2) Sustainable fisheries and aquaculture (http://www.dfo-mpo.gc.ca/science/Publications/framework-cadre/index-eng.htm).

The material presented in this technical report is intended to be complementary to the Royal British Columbia Museum (RBCM) handbooks on sea cucumbers; sea stars; brittle stars, sea urchins and feather stars of British Columbia, southeast Alaska and Puget Sound (Lambert 1997, Lambert 2000, Lambert and Austin 2007). These RBCM handbooks should be consulted to provide a basic introduction to echinoderms classes, their basic anatomy, and glossaries of terminology used in the identification of species in this publication. The RBCM handbooks cover all the echinoderm species which occur in depths ranging from the intertidal to 200 m, while this paper describes those species which occur exclusively below a depth of 200 m off the coast of British Columbia (although they may occur in less than 200 m in other parts of their range). In this publication approximately 100 species of deep-sea echinoderms are described and figured, including eight crinoids, 11 echinoids, 20 ophiuroids, 12 holothuroids and 52 asteroids. These numbers include three new species of crinoid and two new species of asteroid. Species accounts include *Synonyms, Diagnostic Characters, Type Locality, Material Examined, Known Distributions, New Distributions*, and other notes about biology or taxonomy.

All the material that was described off the continental slope of British Columbia was collected from a series of deep-water trawl surveys conducted by the Shellfish Section of Fisheries and Oceans Canada (DFO) at the Pacific Biological Station from 1999 – 2006 (Boutillier and Gillespie 2005). Sampling stations for the trawl surveys are shown in Figure 1 (A), and range from latitudes of approximately 48 – 55 degrees north. Note that the name Haida Gwaii now officially replaces "Queen Charlotte Islands" (Province of BC, Integrated Land Management Bureau, BC Geographical Names Information System, http://ilmbwww.gov.bc.ca/bcgn-bin/bcg10?name=38615). Species accounts include a smaller version of Figure 1 (A) showing the location of the species off British Columbia. Figure 1 (B) and (C) should be referred to for geographic names mentioned thoughout the text. Type localities were taken from the original descriptions except where noted, and additional data for Albatross stations were obtained from the Smithsonian Institution at http://invertebrates.si.edu/albatross/albatross.cfm. Other records of species were obtained from the literature rather than from unpublished records in museum collections.



A) Sampling Locations

B) Haida Gwaii

C) West Coast Vancouver Island

Alaska
British Columbia
Haida Gwaii
QCS
Vancouver Island
Pacific Ocean
JDFS
Washington
Prince of Wales Island (Alaska)
Langara Island
Dixon Entrance
Graham Island
Port Louis
Rennel Sound
Skidegate Channel
Moresby Island
Englefield Bay
Tasu Sound
Gowgaia Bay
Cape St. James
Burke Channel
Triangle Island
Cape Scott
Quatsino Sound
Vancouver Island
Brooks Peninsula
Kyuqyot Sound
Nootka Sound
Barkley Sound
La Perouse Bank
Cape Flattery

Figure 1. A) Sampling locations (red dots) for deep-sea echinoderms in waters off British Columbia, Canada (QCS = Queen Charlotte Sound; JDFS = Juan de Fuca Strait); B) Haida Gwaii detail ; C) West Coast Vancouver Island detail.

Checklist of Echinoderm Species known for British Columbia

This checklist contains all the species known from British Columbia and immediately adjacent areas. Species in **bold** do not occur in less than 200 metres in BC and are described in detail in this report. The provided depth range (metres) applies to the entire geographic range of the species, and may be shallower than 200 m outside BC. Species not yet recorded in BC but occurring nearby, to the north and south of BC, have been included in the list with *. Other species in the list occur in waters shallower than 200 m (on the continental shelf) and are described in the lead author's handbooks (Lambert 1997, Lambert 2000, Lambert and Austin 2007).

This checklist is based on the information in the three echinoderm handbooks mentioned above and unpublished data from the collections of the Royal BC Museum and Dr. Bill Austin. Many references in the primary literature were consulted for distribution. The classifications are based primarily on the Treatise on Invertebrate Paleontology (Moore 1966), but ophiuroid classification is based on Smith et al. (1995). The deep water collections of DFO have produced several undescribed species that are being prepared for publication separate from this report.

Except where noted, photographs and drawings are by the authors.

CLASS CRINOIDEA: Sea Lilies and Feather Stars (5 species in BC)

Family Hyocrinidae
***Gephyrocrinus* n. sp. Roux and Lambert, in prep. .... 1859 – 1903 m (p. 13)**
***Ptilocrinus n.* sp. Roux and Lambert, in prep. .... 1164 – 2105 m (p. 14)**
***Ptilocrinus pinnatus* A.H. Clark, 1907 (Five-Armed Sea Lily) .... 2904 m (p. 15)**

Order Bourgueticrinida
Family Bathycrinidae
***Bathycrinus pacificus* A.H. Clark, 1907* (Ten-armed Abyssal Sea Lily) .... 1655 m (p. 16)**

Order Comatulida
Family Pentametrocrinidae
***Pentametrocrinus paucispinulus* Messing, 2008* .... 1768 m (p. 17)**
***Pentametrocrinus varians* (Carpenter, 1882)* .... 457 – 2727 m (p. 18)**
Family Antedonidae
Florometra serratissima (A.H. Clark, 1907) (Common Feather Star) .... 11 – 1252 m
***Retiometra alascana* A.H. Clark, 1936* (Alaska Feather Star) .... 291 – 1270 m (p. 19)**
Family Zenometridae
***Psathyrometra fragilis* (A.H. Clark, 1907) (Fragile Feather Star) .... 439 – 2903 m (p. 20)**

CLASS ECHINOIDEA: Sea Urchins and Sand Dollars (8 species in BC)

Order Cidaroida
Family Cidaridae
***Aporocidaris fragilis* Agassiz and Clark, 1907* .... 3000 – 4000 m (p. 23)**
***Aporocidaris milleri* Agassiz, 1898* .... 850 - 4300 m (p. 24)**

Order Echinothurioida
Family Echinothuriidae (Soft Sea Urchins)
***Sperosoma biseriatum* Doderlein, 1901 .... 1019 – 3500 m (p. 25)**

***Sperosoma giganteum* Agassiz and Clark, 1907*................................ 1211 m (p. 26)**

Order Echinoida
Family Strongylocentrotidae
Strongylocentrotus droebachiensis (Müller, 1776) (Green Sea Urchin) .... 0 – 300 m
Strongylocentrotus fragilis Jackson, 1912 (Pink Sea Urchin) .... 50 – 1200 m
Strongylocentrotus franciscanus (Agassiz, 1863) (Red Sea Urchin)......................... 0 – 125 m
Strongylocentrotus pallidus (Sars, 1871) (White Sea Urchin)................................ 5 – 1600 m
Strongylocentrotus purpuratus (Stimpson, 1857) (Purple Sea Urchin)..................... 0 – 161 m

Order Clypeasteroida
Suborder Scutellina
Family Dendrasteridae
Dendraster excentricus (Eschscholtz, 1831) (Pacific Sand Dollar).......................... 0 – 232 m

Order Holasteroida
Family Urechinidae
***Cystechinus loveni* Agassiz, 1898* (Pyramid Sea Urchin) ....2600 - 4080 m (p. 27)**
Family Pourtalesiidae (Deep-sea Urchins)
***Ceratophysa ceratopyga valvaecristata* Mironov, 1976*................................4200 – 6320 m (p. 28)**
***Cystocrepis setigera* (Agassiz, 1898)* ....2876 – 4072 m (p. 29)**
***Echinocrepis rostrata* Mironov, 1973* ....3315 – 5020 m (p. 30)**

Pourtalesia *tanneri* Agassiz, 1898***..1450 – 3954 m (p. 31)**

Pourtalesia thomsoni Mironov, 1976***...3315 – 4321 m (p. 32)**

Order Spatangoida
Family Schizasteridae
Brisaster latifrons (Agassiz, 1898) (Heart Urchin)..20 – 1900 m
Family Aeropsidae
***Aeropsis fulva* (Agassiz, 1898)* (Oblong Sea Urchin) ....1463 – 5390 m (p. 33)**

CLASS OPHIUROIDEA: Basket Stars and Brittle Stars (44 species in BC)

Subclass Ophiuridea
Order Euryalida
Family Asteronychidae
Asteronyx loveni Müller and Troschel, 1842 (Snake Brittle Star) .... 115 – 2963 m
Family Gorgonocephalidae (Basket Stars)
Gorgonocephalus eucnemis Müller and Troschel, 1842 (Basket Star).................. 10 – 2000 m
Family Asteroschematidae
***Asteroschema sublaeve* Lütken and Mortensen, 1899 ....605 – 1909 m (p. 38)**

Order Ophiurida (Brittle Stars)
Suborder Ophiomyxina
Family Ophiomyxidae
***Ophioscolex corynetes* (H.L. Clark, 1911) (Fleshy Brittle Star) ....538 – 1253 m (p. 39)**

Suborder Ophiurina

Family Ophiacanthidae		
Ophiacantha bathybia **H.L. Clark,** 1911	**1587 – 6450 m**	**(p. 40)**
Ophiacantha cataleimmoida H.L. Clark, 1911	130 – 1940 m	
Ophiacantha diplasia H.L. Clark, 1911	71 – 1330 m	
Ophiacantha eurypoma **H.L. Clark,** 1911	**1394 – 2869 m**	**(p. 41)**
Ophiacantha normani Lyman, 1879	37 – 2600 m	
Ophiacantha rhachophora **H.L. Clark,** 1911	**50 – 1700 m**	**(p. 42)**
Ophiacantha trachybactra **H.L. Clark,** 1911	**406 – 2014 m**	**(p. 43)**
Ophiolimna bairdi **(Lyman, 1883)**	**521 – 2600 m**	**(p. 44)**
Infraorder Chilophiurina		
Family Ophiuridae		
Subfamily Ophiurinae		
Amphiophiura bullata pacifica **Litvinova, 1971**	**2507 – 6380 m**	**(p. 45)**
Stegophiura ponderosa (Lyman, 1878)	137 – 1436 m	
Amphiophiura superba **(Lütken and Mortensen, 1899)**	**825 – 1867 m**	**(p. 46)**
Ophiocten hastatum **Lyman, 1878**	**916 – 2877 m**	**(p. 47)**
Ophiosphalma jolliense **(McClendon, 1909) (Tile Brittle Star)**	**155 – 2105 m**	**(p. 48)**
Ophiura **bathybia H.L.** Clark, 1911*	**2869 – 4872 m**	**(p. 49)**
Ophiura cryptolepis **H.L. Clark,** 1911	**420 – 1280 m**	**(p. 50)**
Ophiura flagellata **(Lyman, 1878)**	**128 – 2014 m**	**(p. 51)**
Ophiura leptoctenia H.L. Clark, 1911	27 – 3239 m	
Ophiura luetkenii (Lyman, 1860) (Banded Brittle Star)	0 – 1097 m	
Ophiura sarsii Lütken, 1855 (Common Grey Brittle Star)	0 – 1898 m	
Stegophiura carinata **D'yakonov, 1954**	**950 – 2300 m**	**(p. 52)**
Infraorder Gnathophiurina		
Superfamily Gnathophiuridae		
Family Amphiuridae		
Amphiodia occidentalis (Lyman, 1860)	0 – 367 m	
Amphiodia periercta H.L. Clark, 1911	9 – 315 m	
Amphiodia urtica (Lyman, 1860)	0 – 1624 m	
Amphioplus euryaspis (H.L Clark, 1911)	124 – 582 m	
Amphioplus macraspis (H.L. Clark, 1911)	7 – 1400 m	
Amphioplus strongyloplax (H.L. Clark, 1911)	4 – 1408 m	
Amphipholis pugetana (Lyman, 1860)	4 – 1620 m	
Amphipholis squamata (Delle Chiaje, 1829)	0 – 823 m	
Amphiura diomedeae **Lütken and Mortensen, 1899**	**71 – 3030 m**	**(p. 53)**
Subfamily Amphilepidinae		
Amphilepis patens **Lyman, 1879**	**1790 – 3608 m**	**(p. 54)**
Family Ophiotrichidae		
Ophiothrix spiculata Le Conte, 1851 (Glass-spined Brittle Star)	0 – 2059 m	
Family Ophiactidae		
Ophiopholis aculeata Linnaeus, 1767 (Atlantic Daisy Brittle Star)	0 – 366 m	
Ophiopholis bakeri McClendon, 1909 (Baker's Brittle Star)	9 – 1006 m	
Ophiopholis japonica Lyman, 1879 (Japanese Daisy Brittle Star)	15 – 1884 m	
Ophiopholis kennerlyi Lyman, 1860 (Daisy Brittle Star)	0 – 732 m	
Ophiopholis longispina H.L.Clark, 1911 (Long-spined Ophiopholis)	51 – 1746 m	
Superfamily Ophiocomidea		
Family Ophiocomidae		

Ophiopteris papillosa Lyman, 1875 (Glass-spined Brittle Star)........................0 – 170 m

Infraorder Ophiolepidina
Family Ophiolepididae
***Ophiomusium glabrum* Lütken and Mortensen, 1899**........................**878 – 4082 m** **(p. 55)**
***Ophiomusium lymani* Wyville Thompson, 1873 (Lyman's Deep-sea Brittle Star)**........................**130 – 3435 m** **(p. 56)**
***Ophiomusium multispinum* H.L. Clark, 1911**........................**878 – 3219 m** **(p. 57)**
Ophioplocus esmarki Lyman, 1874 (Esmark's Brittle Star)........................0 – 74 m

CLASS HOLOTHUROIDEA: Sea Cucumbers (47 species in BC)

Subclass Aspidochirotacea

Order Aspidochirotida
Family Stichopodidae
Parastichopus californicus (Stimpson, 1857) (California Sea Cucumber)........................0 – 249 m
Parastichopus leukothele Lambert, 1986 (White-spined Sea Cucumber)........................24 – 285 m
Family Synallactidae
***Capheira mollis* Ohshima, 1915**........................**1353 – 2200 m** **(p. 60)**
***Capheira sulcata* Ludwig, 1893**........................**706 – 3400 m** **(p. 61)**
***Mesothuria murrayi* (Théel, 1886)**........................**483 – 2515 m** **(p. 62)**
***Paelopatides confundens* Théel, 1886**........................**1986 – 4069 m** **(p. 63)**
Pseudostichopus mollis Théel, 1886 (Potato Sea Cucumber)........................179 – 2200 m
***Pseudostichopus tuberosus* O'Loughlin and Ahearn, 2005**........................**1859 – 2105 m** **(p. 64)**
Synallactes challengeri (Théel, 1886)........................20 – 366 m

Order Elasipoda (Deep-sea Cucumbers)
Family Laetmogonidae
***Pannychia moseleyi* Théel, 1881**........................**212 – 2598 m** **(p. 65)**
Family Elpidiidae
***Amperima naresi* (Théel, 1882)**........................**1889 – 7130 m** **(p. 66)**
***Scotoplanes theeli* Ohshima, 1915**........................**2100 - 5630 m** **(p. 67)**
***Scotoplanes globosa* (Théel, 1879)**........................**545 - 2500 m** **(p. 68)**
***Peniagone japonica* Ohshima, 1915**........................**1135 – 1669 m** **(p. 69)**

Subclass Dendrochirotacea

Order Dactylochirotida
Family Ypsilothuriidae
***Ypsilothuria bitentaculata* Ludwig, 1893**........................**1318 – 4000 m** **(p. 70)**

Order Dendrochirotida
Family Psolidae
Psolidium bidiscum Lambert, 1996 (Pink Armoured Sea Cucumber)........................0 – 220 m
Psolus chitonoides Clark, 1901b (Orange Armoured Sea Cucumber)........................0 – 247 m
Psolus squamatus (Koren, 1844) (White Armoured Sea Cucumber)........................37 – 1061 m
Family Cucumariidae
Subfamily Cucumariinae
Cucumaria frondosa japonica (Gunnerus, 1767) (Black Sea Cucumber)........................25 – 130 m
Cucumaria miniata (Brandt, 1835) (Orange Sea Cucumber)........................0 – 225 m

Cucumaria pallida Kirkendale and Lambert, 1995 (Pale Sea Cucumber)........................0 – 91 m
Cucumaria piperata (Stimpson), 1864 (Peppered Sea Cucumber)................................0 – 137 m
Cucumaria pseudocurata Deichmann, 1938b (Tar Spot).. intertidal
Cucumaria vegae Théel, 1886 (Northern Tar Spot).. intertidal
Pseudocnus curatus (Cowles, 1907) (Brooding Sea Cucumber)......................................0 – 20 m
Pseudocnus lubricus (H.L. Clark, 1901b) (Aggregating Sea Cucumber)........................0 – 78 m
Subfamily Thyonidiinae
Ekmania diomedeae (Ohshima, 1915)..37 – 220 m
Thyonidium kurilensis (Levin, 1984) (Kurile Sea Cucumber)......................................10 – 228 m
Family Phyllophoridae
Subfamily Thyoninae
Pentamera lissoplaca (H.L. Clark, 1924)..0 – 90 m
Pentamera pediparva Lambert, 1998 (Fine-footed Pentamera)......................................7 – 150 m
Pentamera populifera (Stimpson, 1864) (Common Pentamera).....................................0 – 256 m
Pentamera pseudocalcigera Deichmann, 1938b..22 – 300 m
Pentamera rigida Lambert, 1998 (Stiff Pentamera)...18 – 421 m
Pentamera trachyplaca (H.L. Clark, 1924)...0 – 27 m
Thyone benti Deichmann, 1937 (Bent Sea Cucumber)..0 – 135 m
Family Sclerodactylidae
Eupentacta pseudoquinquesemita Deichmann, 1938b (Pseudo-white Sea Cucumber) 0 – 200 m
Eupentacta quinquesemita (Selenka, 1867) (White Sea Cucumber)...............................0 – 55 m
Pseudothyone levini Lambert and Oliver, 2001 (Levin's Sea Cucumber)........................0 – 70 m

Subclass Apodacea

Order Molpadiida
Family Molpadiidae
***Molpadia musculus* Risso 1826** .... **800 – 3000 m** **(p. 71)**
Molpadia intermedia (Ludwig, 1894) (Sweet Potato Sea Cucumber)..........................7 – 2925 m
Family Caudinidae
***Hedingia californica* (Ludwig, 1894) (Wrinkled White Sea Cucumber)......... 595 – 2850 m** **(p. 72)**
Paracaudina chilensis (Müller, 1850) (Rat-tailed Sea Cucumber)...............................0 – 100 m

Order Apodida
Family Synaptidae
Leptosynapta clarki Heding, 1928 (White burrowing Sea Cucumber)............................0 – 73 m
Leptosynapta transgressor Heding, 1928 (Red-spotted Burrowing Sea cucumber).......6 – 40 m
Family Chiridotidae
Chiridota albatrossii Edwards, 1907 (Jellybean Sea Cucumber)................................46 – 732 m
Chiridota discolor Eschscholtz, 1829 (Intertidal Jellybean)......................... intertidal SE Alaska
Chiridota nanaimensis Heding, 1928...46 m

CLASS ASTEROIDEA: Sea Stars (87 species in BC)

Order Paxillosida
Family Luidiidae
Luidia foliolata Grube, 1866 (Sand Star)...4 – 613 m
Family Astropectinidae
***Dipsacaster anoplus* Fisher, 1910**...**146 – 2200 m** **(p. 77)**
***Dipsacaster borealis* Fisher, 1910**...**201 – 1195 m** **(p. 78)**
***Dispsacaster laetmophilus* Fisher, 1910**...**1271 – 1903 m** **(p. 79)**

Leptychaster anomalus Fisher, 1906 .... 59 – 1258 m
Leptychaster arcticus (Sars, 1851) (Arctic Leptychaster) .... 40 – 1261 m
***Leptychaster inermis* (Ludwig, 1905)* .... 1180 – 2000 m** (p. 80)
Leptychaster pacificus Fisher, 1906 (Pacific Leptychaster) .... 10 – 435 m
***Psilaster pectinatus* (Fisher, 1905) .... 1500 – 3000 m** (p. 81)
***Thrissacanthias penicillatus* (Fisher, 1905) .... 507 – 1503 m** (p. 82)
Family Porcellanasteridae (Deep-sea Mud Stars)
***Eremicaster pacificus* (Ludwig, 1905) .... 1570 – 4090 m** (p. 83)
***Eremicaster crassus* (Sladen, 1883) .... 1570 – 6330 m** (p. 84)
Family Ctenodiscidae
Ctenodiscus crispatus (Retzius, 1805) (Mud Star) .... 10 – 1890 m

Order Notomyotida
Family Benthopectinidae
***Benthopecten acanthonotus* Fisher, 1905 .... 1800 – 2125 m** (p. 85)
***Benthopecten claviger claviger* Fisher, 1910 .... 1100 – 2400 m** (p. 86)
***Benthopecten mutabilis* Fisher, 1910* .... 2870 m** (p. 87)
Cheiraster dawsoni (Verrill, 1880) .... 73 – 384 m
***Nearchaster aciculosus* (Fisher, 1910) .... 84– 1492 m** (p. 88)
***Nearchaster variabilis variabilis* (Fisher, 1910) .... 198 – 1061 m** (p. 89)
***Pectinaster agassizi evoplus* (Fisher, 1910) .... 1100 – 2200 m** (p. 90)

Order Valvatida
Family Asterinidae
Patiria miniata (Brandt, 1835) (Bat Star) .... 0 – 302 m
Family Poraniidae
Poraniopsis inflatus inflatus (Fisher, 1906) .... 11 – 366 m
Family Goniasteridae
Ceramaster arcticus (Verrill, 1909) (Arctic Cookie Star) .... 0 – 186 m
***Ceramaster clarki* Fisher, 1910* .... 611 – 1098 m** (p. 91)
***Ceramaster japonicus* (Sladen, 1889) *(Japanese Cookie Star) .... 195 – 1438** m (p. 92)
Ceramaster patagonicus (Sladen, 1889) (Cookie Star) .... 10 – 245 m
***Cladaster validus* Fisher, 1910 .... 116 – 621** m (p. 93)
***Cryptopeltaster lepidonotus* Fisher, 1905 .... 486 – 1244** m (p. 94)
Gephyreaster swifti (Fisher, 1905) (Gunpowder Sea Star) .... 11 – 344 m
***Hippasteria californica* Fisher, 1905 .... 300 – 2200** m (p. 95)
Hippasteria spinosa Verrill, 1909 (Spiny Red Sea Star) .... 10 – 512 m
Mediaster aequalis Stimpson, 1857 (Vermilion Star) .... 0 – 293 m
***Mediaster tenellus* Fisher, 1905 .... 532 – 2125 m** (p. 96)
***Pseudarchaster dissonus* Fisher, 1910 .... 846 – 2300** m (p. 97)
Pseudarchaster parelii (Duben and Koren, 1846) .... 15 – 2500 m
Pseudarchaster alascensis Fisher, 1905 .... 92 – 1947 m
Family Asteropseidae
Dermasterias imbricata (Grube, 1857) (Leather Star) .... 0 – 91 m

Order Velatida
Family Solasteridae
Crossaster papposus (Linnaeus, 1767) (Rose Star) .... 0 – 1200 m
***Heterozonias alternatus* (Fisher, 1906) .... 302 – 1594 m** (p. 98)
***Lophaster furcilliger* Fisher, 1905 .... 229 – 2125 m** (p. 99)
Lophaster furcilliger vexator Fisher, 1910 .... 21 – 670 m

Solaster borealis **(Fisher, 1906)........161 – 2300 m (p. 100)**
Solaster dawsoni Verrill, 1880 (Morning Sun Star)........0 – 420 m
Solaster endeca (Linnaeus, 1771) (Northern Sun Star)........0 – 475 m
Solaster paxillatus Sladen, 1889 (Orange Sun Star)........11 – 640 m
Solaster stimpsoni Verrill, 1880 (Striped Sun Star)........0 – 60 m
Solaster **sp. A........1291 – 2083 m (p. 101)**
New **Genus sp. B........571 – 621 m (p. 101)**
Family Pterasteridae (Cushion Stars)
Diplopteraster multipes (Sars, 1865)........57 – 1171 m
Hymenaster koehleri **Fisher, 1910*........3239 m (p. 102)**
Hymenaster perissonotus **Fisher, 1910........412 – 3239 m (p. 103)**
Hymenaster quadrispinosus **Fisher, 1905........1097 – 3610 m (p. 104)**
Pteraster coscinopeplus **Fisher, 1910........857 – 1942 m (p. 105)**
Pteraster jordani **Fisher, 1905........457 – 1903 m (p. 106)**
Pteraster marsippus **Fisher, 1910*........95 – 642 m (p. 107)**
Pteraster militaris (Müller, 1776) (Wrinkled Star)........10 – 1100 m
Pteraster tesselatus Ives, 1888 (Slime Star)........6 – 436 m
Pteraster trigonodon **Fisher, 1910........706 – 1259 (p. 108)**
Family Myxasteridae
Asthenactis fisheri **Alton, 1966 (Mucous Star)........1152 – 1922 m (p. 109)**
Family Korethrasteridae
Peribolaster biserialis **Fisher, 1905*........104 – 805 m (p. 110)**

Order Spinulosida
Family Echinasteridae
Henricia aspera aspera Fisher, 1906 (Ridged Blood Star)........6 – 904 m
Henricia asthenactis Fisher 1910........91 – 1250 m
Henricia clarki **Fisher, 1910........227 – 1955 m (p. 111)**
Henricia leviuscula leviuscula (Stimpson, 1857) (Blood Star)........0 – 400 m
Henricia leviuscula annectens Fisher, 1910........10 – 228 m
Henricia leviuscula spiculifera Clark, 1901........9 – 680 m
Henricia longispina longispina Fisher, 1910........28 – 512 m
Henricia polyacantha **Fisher, 1906........227 – 1171 m (p. 112)**
Henricia sanguinolenta (Müller, 1776) (Fat Henricia)........15 – 518 m

Order Forcipulatida (Sea Stars with pedicellariae)
Family Zoroasteridae
Myxoderma sacculatum **(Fisher, 1905)........329 – 2012 m (p. 113)**
Sagenaster evermanni **(Fisher, 1905)........100 -- 2710 m (p. 114)**
Zoroaster ophiurus **Fisher, 1905........696 – 2300 m (p. 115)**
Family Asteriidae
Evasterias troschelii (Stimpson, 1862) (Mottled Star)........0 – 75
Leptasterias aequalis sp. Complex (Six-armed Star)........intertidal/shallow
Leptasterias alaskensis sp. complex........intertidal/shallow
Leptasterias hexactis sp. Complex (Six-armed Star)........intertidal/shallow
Leptasterias coei Verrill, 1914*........18 – 187 m
Leptasterias polaris katherinae (Grey, 1840)........intertidal to 10 m
Lethasterias nanimensis (Verrill, 1914)*........0 – 224 m
Orthasterias koehleri (de Loriol, 1897) (Rainbow Star)........0 – 230 m
Pisaster brevispinus (Stimpson, 1857) (Giant Pink Star)........0 – 128 m
Pisaster ochraceus (Brandt, 1835) (Purple Star, Ochre Star)........0 – 97 m

Pycnopodia helianthoides (Brandt, 1835) (Sunflower Star)	0 – 120 m	
Stylasterias forreri (de Loriol, 1887) (Long-rayed Star)	6 – 532 m	
Family Pedicellasteridae		
Ampheraster marianus **(Ludwig, 1905)**	**507 – 1240 m**	**(p. 116)**
Anteliaster coscinactis **Fisher, 1923**	**817 – 950 m**	**(p. 117)**
Pedicellaster magister **Fisher, 1923**	**77 – 1776 m**	**(p. 118)**
Tarsaster alaskanus **Fisher, 1928**	**198 – 2100 m**	**(p. 119)**
Family Labidiasteridae		
Rathbunaster californicus **Fisher, 1906**	**134 – 675 m**	**(p. 120)**
Order Brisingida		
Family Brisingidae (Deep-sea Suspension feeders)		
Brisinga synaptoma **(Fisher, 1917)**	**1353 – 3176 m**	**(p. 121)**
Family Freyellidae		
Astrocles actinodetus **Fisher, 1917**	**2870 – 4200 m**	**(p. 122)**
Freyella microplax **(Fisher, 1917)**	**1722 – 3176 m**	**(p. 123)**
Freyellaster fecundus **(Fisher, 1905)**	**880 – 2124 m**	**(p. 124)**
Family Hymenodiscididae (after Mah 1997)		
Astrolirus panamensis **(Ludwig, 1905)**	**1353 – 2418 m**	**(p. 125)**
Hymenodiscus pannychia **(Fisher, 1928)**	**1410 – 2300 m**	**(p. 126)**
Hymenodiscus pusilla **(Fisher, 1917)**	**602 – 2118 m**	**(p. 127)**

Species Accounts

CLASS CRINOIDEA: Sea Lilies and Feather Stars

Key to the deep-sea crinoids of British Columbia, Canada. See Figure 2 for important anatomical features and page 139 for a glossary of terms. Also consult Lambert and Austin (2007) for shallow water crinoids and Roux et al. (2002) for stalked crinoids.

1a	Crinoids attached to substrate with a stalk	2
1b	Unstalked crinoids with numerous cirri at base	5
2a	Five arms	3
2b	Ten arms	*Bathycrinus pacificus* (p. 16)
3a	Stalk and crown smooth	4
3b	Stalk and crown with bumps and ridges	*Gephyrocrinus n. sp.*(p. 13)
4a	Small; stalk diameter <2.5 mm; <30 pinnules per arm side; base of pinnule not inflated for gonad	*Ptilocrinus pinnatus* (p. 15)
4b	Large; stalk diameter >3.0 mm; >30 pinnules per arm side; arms with about 60 segments; base of pinnule inflated	*Ptilocrinus* n. sp (p. 14)
5a	Five arms	6
5b	Ten arms	7
6a	Up to 30 cirri, 30-50 mm long, up to 22 segments; **distal** segments tapering to a point ; brachials smooth; disk black	*Pentametrocrinus varians* (p. 18)
6b	Up to 41 cirri, up to 27 mm long, up to 22 segments; terminal claw curved; lowest brachials with 1-3 small spines; disk plated	*Pentametrocrinus paucispinulus* (p. 17)
7a	Centrodorsal a truncated cone, about as tall as wide at the base, or taller	*Psathyrometra fragilis* (p. 20)
7b	Centrodorsal a flattened hemisphere, always wider than tall	8
8a	Small; arm length to 75 mm; up to 60 delicate cirri to 8 mm long with 12 segments	*Retiometra alascana* (p. 19)
8b	Large; arm length to 235 mm; up to 80 cirri to 70 mm long with up to 53 segments	*Florometra serratissima* (includes synonym *F. asperrima*).

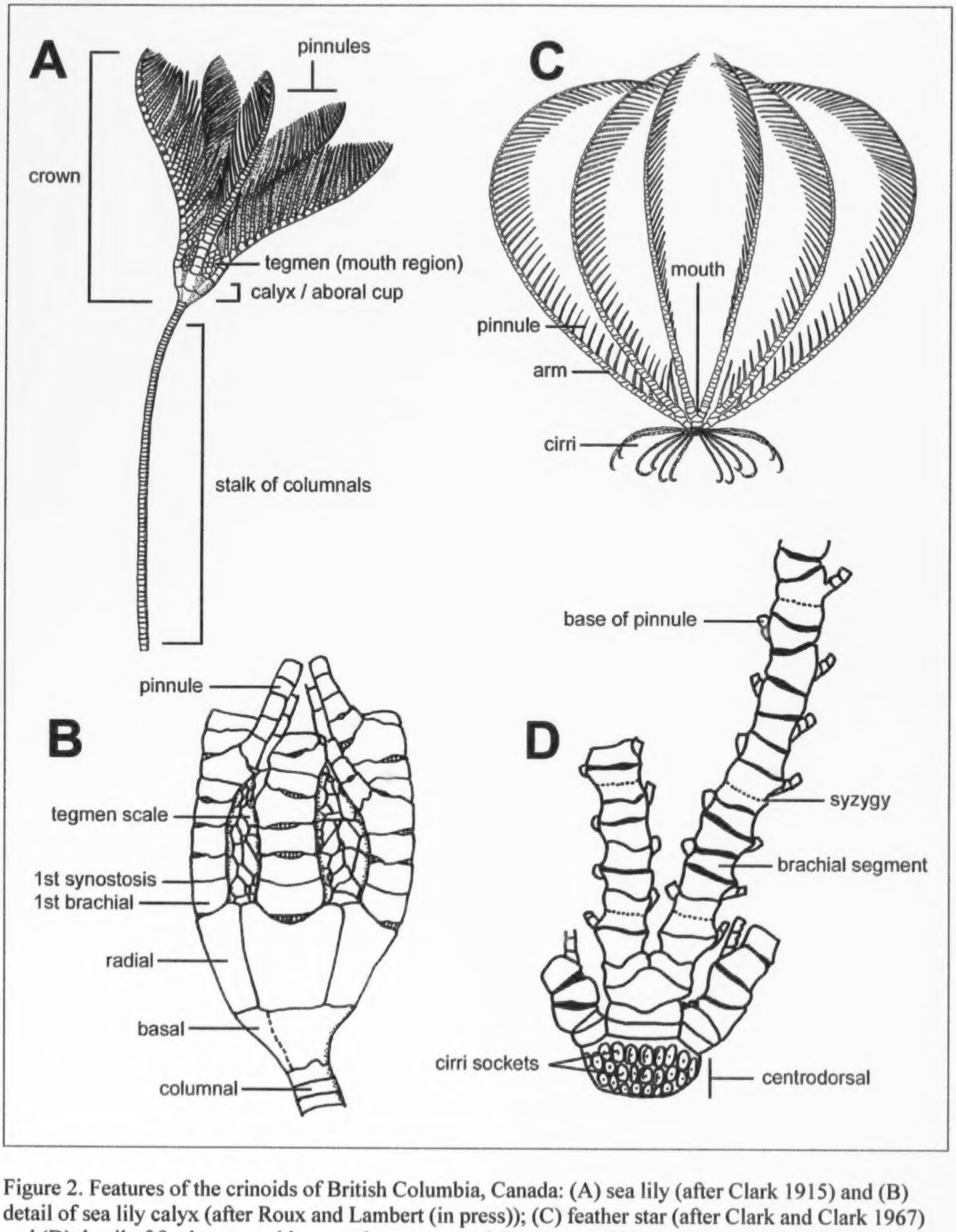
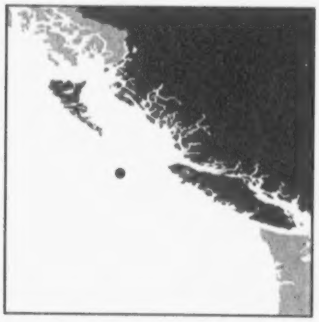

A
pinnules
crown
tegmen (mouth region)
calyx / aboral cup
stalk of columnals
C
mouth
pinnule
arm
cirri
pinnule
B
tegmen scale
1st synostosis
1st brachial
radial
basal
columnal
base of pinnule
D
syzygy
brachial segment
cirri sockets
centrodorsal

Figure 2. Features of the crinoids of British Columbia, Canada: (A) sea lily (after Clark 1915) and (B) detail of sea lily calyx (after Roux and Lambert (in press)); (C) feather star (after Clark and Clark 1967) and (D) detail of feather star with appendages removed (Lambert 2007).



Order Hyocrinida
Family Hyocrinidae

Gephyrocrinus n. sp. Roux and Lambert, in prep

Diagnostic Characters: Proximal arm pattern 1+2 3 4 5+6 7+8; **first pinnule on fourth brachial (1)**; similar to *P. pinnatus* but tegmen with **verrucose ornamentation (2)** and **conical aboral cup with radial ribs and transverse ridges (3)**; anal cone bottle-shaped and about the same height as the oral cone.

Material Examined: One specimen from 1859 – 1903 m, northwest of Cape Scott, Vancouver Island.

Type Locality: DFO T2006-07, off Cape Scott, Vancouver Island, Queen Charlotte Sound (50°26'56" N, 130°07'17" W), 1859 – 1903 m.

Remarks: This specimen is being studied by Dr. Michel Roux, Paris, France along with two other specimens of this new species from off California.

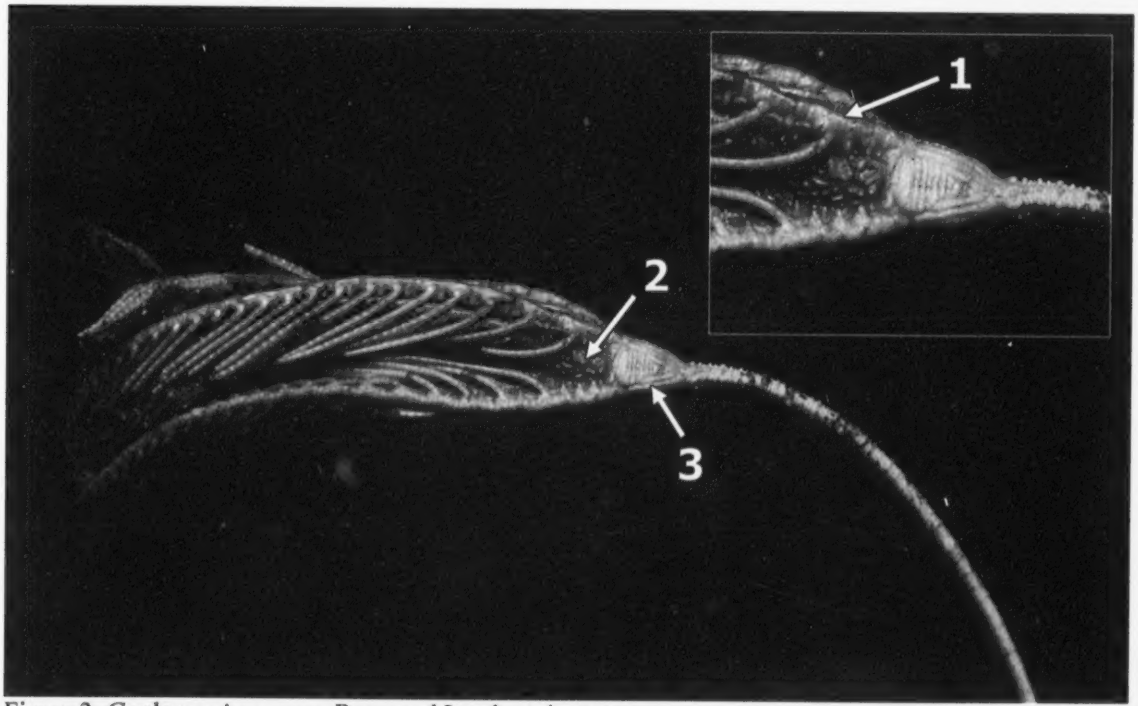
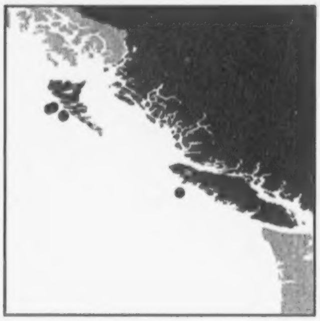


Figure 3. *Gephyrocrinus* n. sp. Roux and Lambert, in prep.



Ptilocrinus n. sp. Roux and Lambert, in prep.

Diagnostic Characters: Large species with proximal-most diameter of stalk more than 3.0 mm. 30 pinnules or more per arm side (up to 45). **Five unbranched arms (1)** of about 60 segments; synostoses usually between 1st and 2nd brachial, then at 5+6 and 7+8 or 8+9 and variable after that. Base of pinnules with genital inflation with lateral plates on two sides. Tegmen height up to 11th brachial; 50 or more flat irregularly polygonal tegminal plates. Ratio of height to diameter of columnals less than 0.6. Usually 3 – 7 successive muscular joints in mid arm. **Stem smooth, slender and flexible (2). Colour yellow (3).**

Material Examined: Fifty-eight specimens in five lots from 1164 – 2105 m between Kyuquot Sound,Vancouver Island and Skidegate Channel, Haida Gwaii

Type Locality: DFO T2004-10, off Kyuquot Sound, Vancouver Island (49°42'01" N, 127°57'98" W), 1625 – 1922 m.

Remarks: These specimens were initially identified as *Ptilocrinus pinnatus* but after detailed examination they have been described as a new species (Roux and Lambert, in prep).

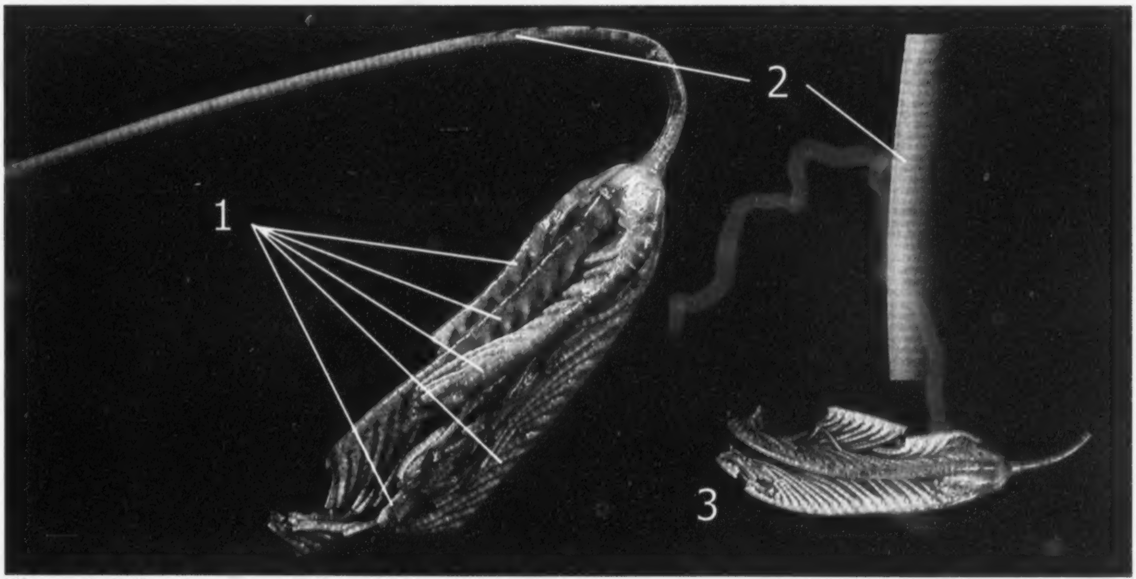
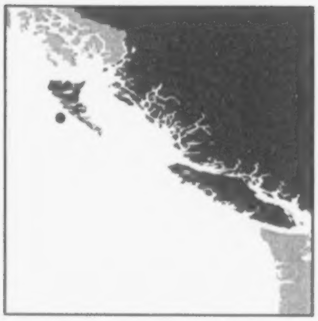


Figure 4. *Ptilocrinus* n. sp. Roux and Lambert, in prep.



Ptilocrinus pinnatus **A.H. Clark, 1907**
Five-Armed Sea Lily

Diagnostic Characters: Small species; diameter of proximal-most stalk (Dp) less than 2.5 mm and a maximum of 30 pinnules per arm side. Ratio of height to diameter of columnals about 0.7. Usually 6 – 10 successive muscular joints in mid arm. Location of synostoses 1+2 3 4 5+6 7 8+9 . Proximal part of pinnules with one row of low lateral plates without inflation for the gonads. Tegmen height up to brachial 8; 25 to 40 regular tegminal plates.

Material Examined: None collected in this study.

Type Locality: Albatross 3342, off Tasu Sound, Haida Gwaii (52°39'30" N, 132°38'00" W), 1588 fms (2904 m), gray ooze and coarse sand.

Known Distribution: Known only from type specimen, three paratypes, and 14 stems and pieces at the type locality (A.H. Clark 1907a).

Remarks: In this study, the specimens now identified as *Ptilocrinus* n. sp. (Figure 4) were initially identified as *P. pinnatus*. This latter species is only known from BC waters but it was not collected during this study, perhaps because it occurs in deeper water than sampled.

Order Bourgueticrinida
Family Bathycrinidae

Bathycrinus pacificus A.H. Clark, 1907

Ten-armed Abyssal Sea Lily

Diagnostic Characters: Light yellow stalked crinoid with **ten arms (1)**; **stem about 100 segments (2)**; 1st pinnule is on the **8th brachial (3)**.

Material Examined: None collected in this study.

Type Locality: Albatross 4974, south of Shiono Misaki, Honshu Island, Japan (33°18'10" N, 135°40' 50"E), 905 fms (1655 m), brown and green mud.

Known Distribution: Only known from type locality at 1655 m.

Remarks: No records for BC but might occur in abyssal depths off this coast.

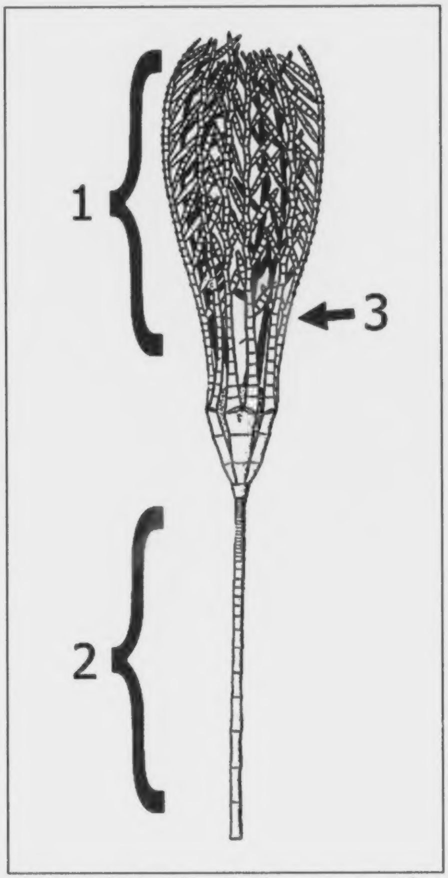


Figure 5. Ten-armed Abyssal Sea Lily, *Bathycrinus pacificus* A.H. Clark, 1907.
Drawing after A.H. Clark 1907b.

Order Comatulida
Family Pentametrocrinidae

Pentametrocrinus paucispinulus Messing, 2008

Diagnostic Characters: A small species with five unbranching **arms (1).** Mouth very large and central with anal papilla marginal. Oral disk covered with close-fitting irregular plates, many with a small round tubercle. The **first pinnule is on the 2nd brachial (2)**; first syzygy between brachial 4 and 5 (Br $_{4+5}$); the **centrodorsal (3)** is a low hemisphere about 5mm wide, with 41 cirri up to 27 mm long. Proximal brachials with a small proximolateral spine or mid-aboral spine, or both.

Material Examined: None collected in this study.

Type Locality: Monterey Bay Aquarium Research Institute Sample T627, Pioneer Seamount off San Francisco, California (37° 23.8' N, 123° 26.6' W), 1768 m, black lava.

Known Distribution: Only known from the type locality.

Remarks: *P. varians* (see following account) is reported from off northern Washington (Austin 1985) but that species was previously only known from Japan and Indonesia so the identification is perhaps questionable. The Washington specimen may turn out to be the newly described *P. paucispinulus* but so far no example of either species in this genus has been collected in BC.

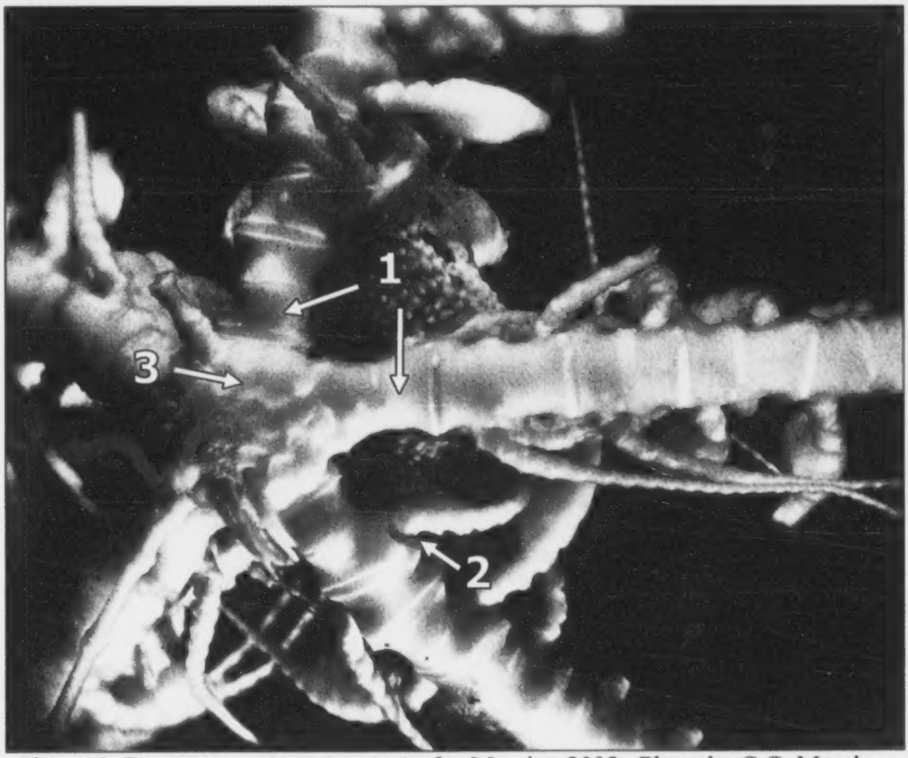


Figure 6. *Pentametrocrinus paucispinulus* Messing 2008. Photo by C.G. Messing.

Pentametrocrinus varians (Carpenter, 1882)

Synonyms: *Eudiocrinus varians*

Diagnostic Characters: Dull purplish brown feather star with white cirri and a black disk. Five arms; lowest pinnule is on the 2nd brachial; centrodorsal, low hemispherical, with large bare polar area; cirrus sockets in 2 rows; long slender cirri; syzygies at 4+5, 9+10, 11+12, 13+14, then intervals of 2 – 8 distally.

Material Examined: None collected in BC.

Type Locality: Challenger 205, off the Philippine Islands (16° 42' N, 119° 22' E), 1050 fms (1920 m).

Known Distribution: From the vicinity of Andaman and Maldive Islands and Lesser Sunda Islands, 457 – 2727 m (Clark and Clark 1967) to southern half of Japan in 660 – 1302 m (A.H. Clark 1907b) and off northern Washington State (Austin 1985).

Remarks: Not yet collected in BC but if the Austin record is confirmed then we can expect it in BC.

Other References: Clark and Courtman-Stock (1976).

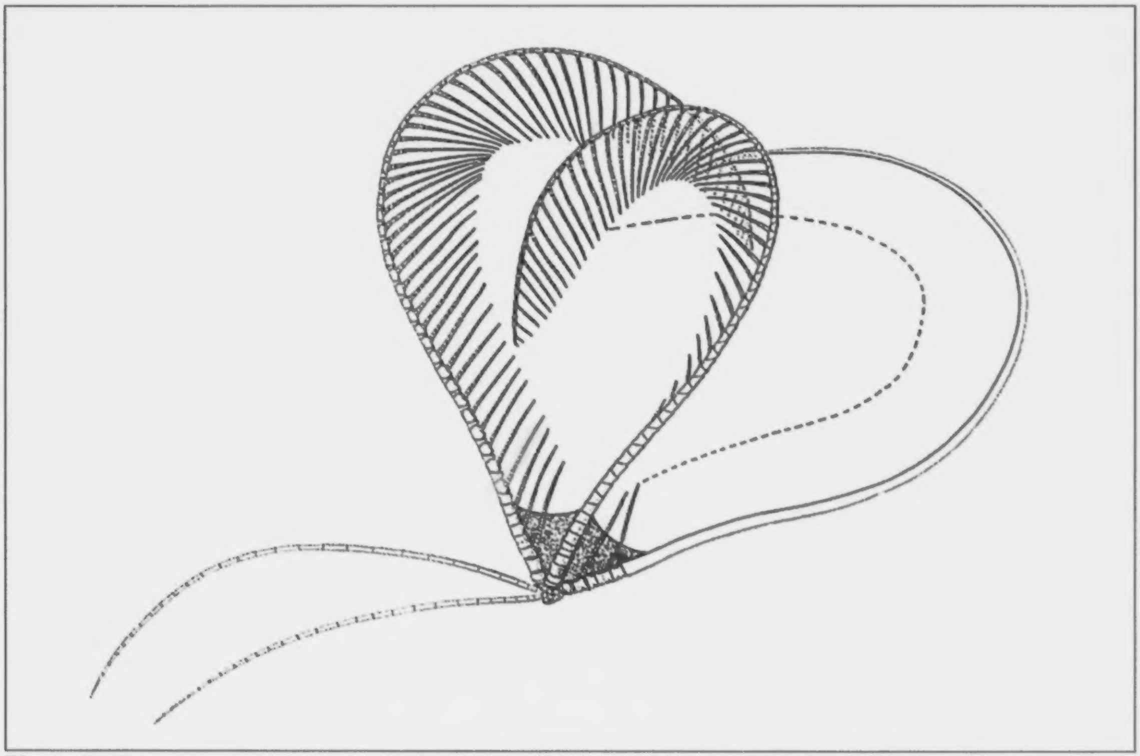


Figure 7. *Pentametrocrinus varians* (Carpenter, 1882). Drawing after Clark and Clark (1967).

Family Antedonidae (Feather Stars)

Retiometra alascana **A.H. Clark, 1936**
Alaska Feather Star

Diagnostic Characters: Small feather star with10 arms, 55 – 75 mm long. 1st pinnule very long with elongate segments; **syzygies (1)** at 3+4, 9+10, 14+15 then distally every 2 segments. Centrodorsal very low with broad **bare dorsal pole (2)** about 1/3 diameter of centrodorsal in width; 45 – 60 **cirrus sockets (3)** closely crowded and increase slowly in size from dorsal pole.

Material Examined: None collected in this survey.

Type Locality: Albatross 3330, north of Unalaska Island, Aleutian Islands, Alaska (54° 00' 45" N, 166° 53' 50" W), 351 fms (642 m), black sand and mud.

Previous Known Distribution: Southeastern Bering Sea and Gulf of Alaska; 291 – 1270 m (A.H. Clark 1936); deep off Oregon (Alton 1972, Austin 1985). US National Museum web site lists a single specimen from off San Diego identified by C.G. Messing,.

Remarks: Not yet recorded for BC but reported off Oregon and California and often associated with *Florometra asperrima* (=*Florometra serratissima*), which does occur in BC.

Other References: Clark and Clark (1967a).

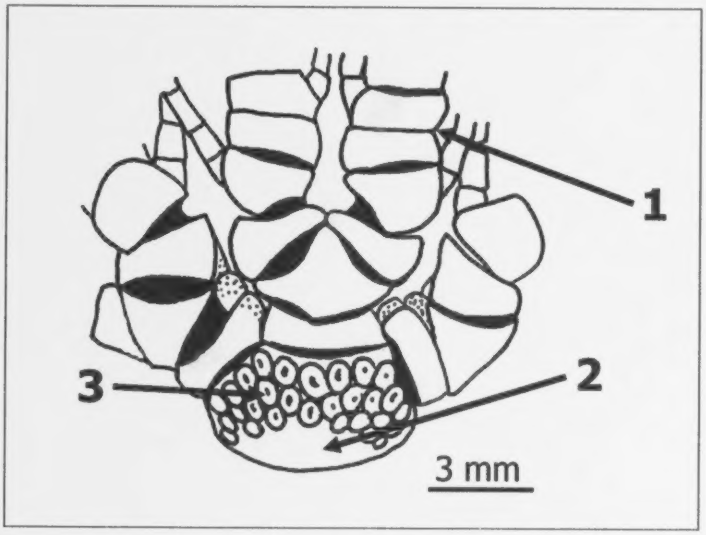
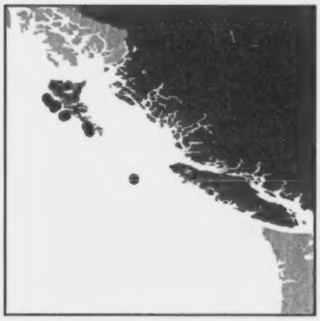


Figure 8. *Retiometra alascana* A.H. Clark, 1936.



Family Zenometridae

Psathyrometra fragilis **(A.H. Clark, 1907)**

Fragile Feather Star

Synonyms: *Antedon fragilis* A.H. Clark, 1907

Diagnostic Characters: Purplish brown feather star with **10 arms (1)**; 40 – 70 cirri of about 30 elongate smooth segments; first two pinnules similar in length and comparatively short (14 mm) with 20 elongated segments; the 3rd is longer and stouter; **syzygial interval 3 sometimes 4 (2)**. Centrodorsal higher than broad; 3 or 4 crowded columns of **cirrus sockets (3)** per radial area.

Material Examined: Twenty-eight specimens in nine lots from 706 – 1903 m, from Queen Charlotte Sound to Rennel Sound, Haida Gwaii.

Type Locality: Albatross 5032, Nemuro Strait, Hokkaido Island, Japan (44°5' N, 145°30'E), 500 fms (914 m), brown mud, fine black sand and gravel.

Known Distribution: Gulf of Panama (Messing and White 2001) and Monterey Bay, California to SE Alaska, Aleutians, Kuriles, Suruga Gulf. 439 – 2903 m (Clark and Clark 1967).

Remarks: Specimens from BC are within the previous known range

Other References: Baranova (1957), A.H. Clark (1937).

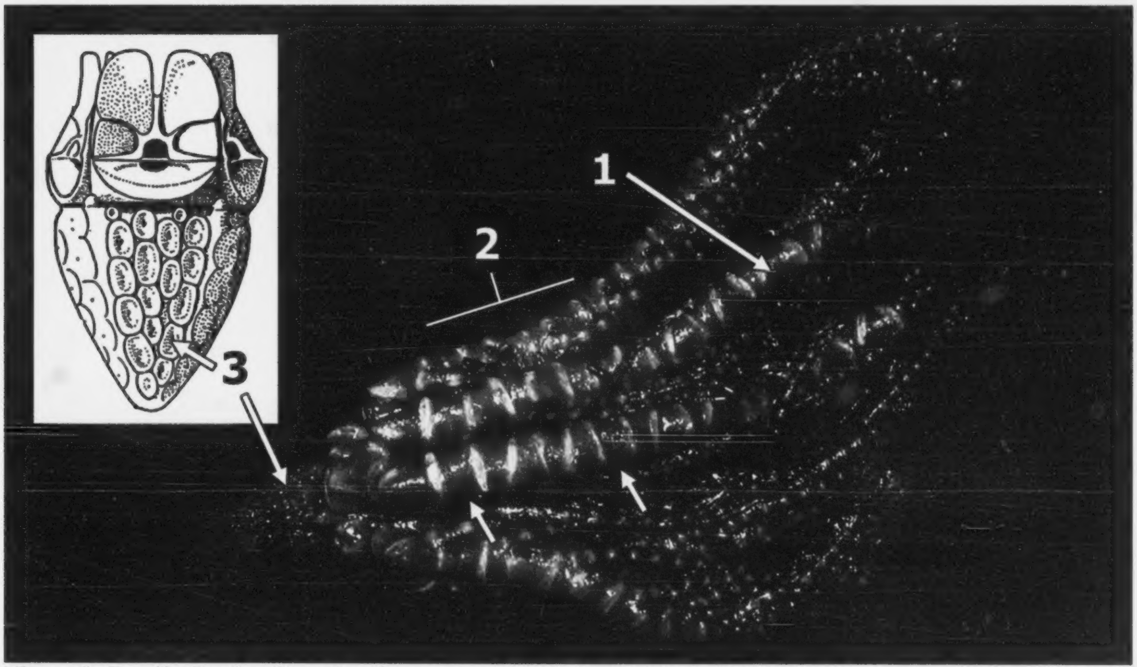


Figure 9. Fragile Feather Star, *Psathyrometra fragilis* (A.H. Clark, 1907). Yellow arrows indicate location of sygyzies at 3+4 and 9+10. Drawing after Clark and Clark (1967a).

CLASS ECHINOIDEA: Sea Urchins and Sand Dollars

Key to the deep-sea echinoids of British Columbia, Canada. See Figure 10 and Figure 11 for sea urchin anatomy and representive features and and page 139 for a glossary of terms. Consult Lambert and Austin (2007) for more about echinoids. In addition, for information on echinoid morphology and classification consult The Echinoid Directory (Smith 2005a) of the British Natural History Museum at http://www.nhm.ac.uk/palaeontology/echinoids.

1a Regularly shaped sea urchin with pentaradial symmetry 2
1b Irregular sea urchins showing bilateral symmetry 3

2a Large, soft, leathery urchin that collapses when collected .... *Sperosoma spp.* (p. 25)
2b Small sea urchin with a firm test and very long primary spines .... *Aporocidaris spp.* (p. 23)

3a Sea urchin with a large thin, pyramid shaped test; subcentral mouth, anus near posterior edge. .... *Cystechinus loveni* (p. 27)
3b Elongate sea urchins shaped like bottles, arrowheads or triangles 4

4a Elongate, oval, laterally compressed. Circular mouth midway between centre and anterior; anus submarginal, visible in aboral view .... *Aeropsis fulva* (p. 33)
4b Mouth sunken in deep oral cavity 5

5a No subanal rostrum. Anus marginal or inframarginal 6
5b Anterior of test not extended and not vase-like but with a posterior rostrum 7

6a Test triangular (base of triangle anterior) .... *Echinocrepis rostrata* (p. 30)
6b Test ovate and without a subanal bulge at rear .... *Cystocrepis setigera* (p. 29)

7a Test with a broad, bilobed anterior end, and a posterior rostrum .... *Ceratophysa ceratopyga valvaecristata* (p. 28)
7b Anterior of test cylindrical or bottle shaped. Posterior ambulacral plating disjunct .... *Pourtalesia spp.* (p. 31)

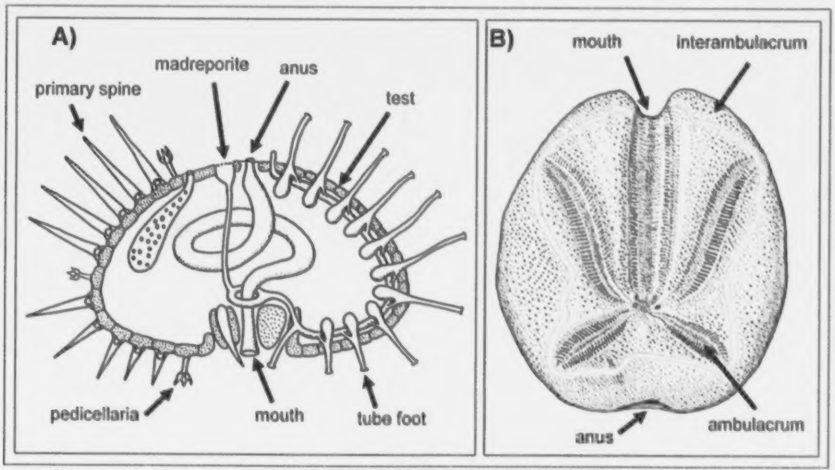


Figure 10. Sea urchin parts: A) regular sea urchins (1a in key) and B) irregular sea urchins (1b in key).

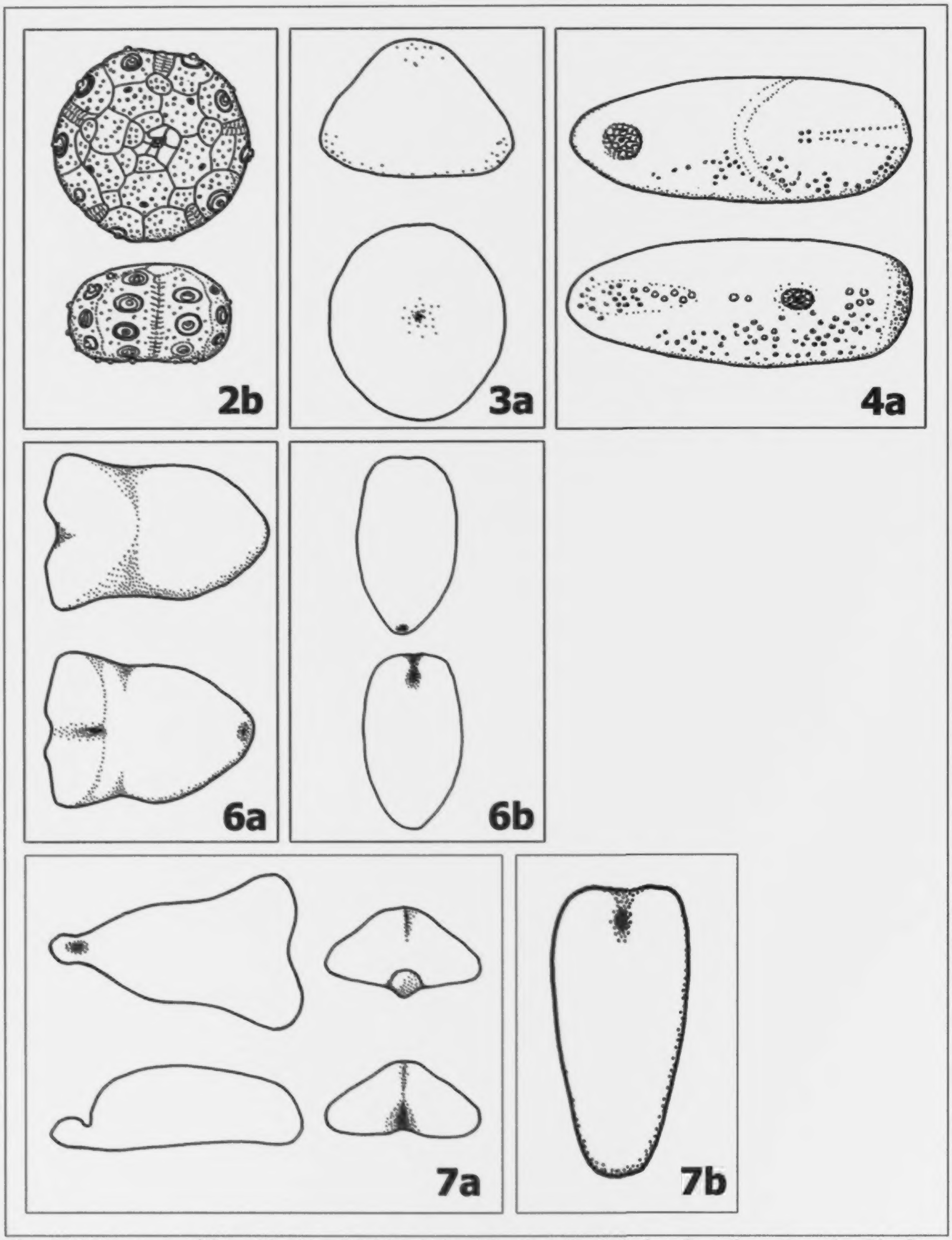


Figure 11. Features of the echinoids of British Columbia, Canada. Labels refer to key. Drawing 2b after RAMS (2009) and 3a – 7b after Aggassiz (1881, 1898, and 1904).

Order Cidaroida
Family Cidaridae

Aporocidaris fragilis **Agassiz and Clark, 1907**
Long-spined sea urchin

Diagnostic Characters: A small (about 23 mm diam.) regular sea urchin with height about 50% of diameter. Few primary spines (about 5 per row) but very long (up to 40 mm) and covered with small pointed tubercles. The lowest primary spines are small and lightly curved, broadened terminally and serrated on the sides. Two kinds of globiferous pedicellariae, “large” and “small,” as illustrated in D’yakonov (1969).

Material Examined: None collected in this study

Type Locality: Bering Sea south of Shumagin Islands, Alaska, 4000 m (D'yakonov 1969).

Known Distribution: Bering Sea south to the Shumagin Islands, Alaska and to the southern tip of Kamchatka, 3000 – 4000 m (D'yakonov 1969).

Remarks: This species from north of BC might be found in deep water off BC.

Aporocidaris milleri Agassiz, 1898

Diagnostic Characters: Small test with long primary spines having fine serrations. The **primary tubercles (1)** are not crenulate. Neither tridentate nor large globiferous pedicellariae occur in this species, but small globiferous ones of very diverse sizes are abundant.

Material Examined: None collected in this study

Type Locality: Albatross 3359, off Cape Mala, Panama (6° 22' 20"N 81°52' 00" W), 465 fms (850 m), rock and sand.

Known Distribution: Panama to Acapulco, Mexico, 900 – 4300 m (D'yakonov 1969); 465-1879 fms (850-3436 m) (Agassiz 1898); off Ecuador, 2005-2153 fms (3667-3937 m) (Agassiz and Clark 1907); 300-3937 m (Lessios 2005).

Remarks: This species that originates south of BC might be found here in deep water.

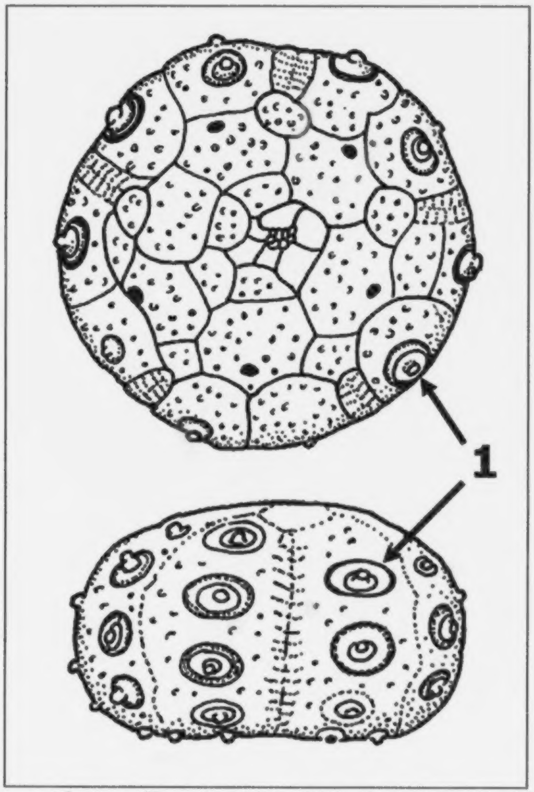
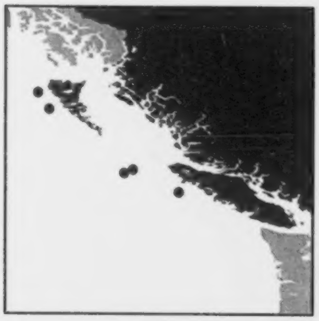


Figure 12. *Aporocidaris milleri* Agassiz, 1898. Drawing after RAMS (2009).



Order Echinothurioida
Family Echinothuriidae (Soft Sea Urchins)

Sperosoma biseriatum Doderlein, 1901

Diagnostic Characters: Large, leathery sea urchin up to 21 cm in diameter, flat when collected. **Purple (1)**. Primary spines only on **oral surface (2)**. Twice as many ambulacral plates on **aboral side (3)** than on oral. Ambulacral podia in two longitudinal rows but each row can be a zigzag rather than a straight line. Only **triphyllous (4)** and **tridentate (5)** pedicellariae.

Material Examined: Six specimens in five lots from 1625 – 2125 m between Brooks Peninsula and the northwest tip of Haida Gwaii.

Type Locality: Indian Ocean near African coast, 1019 m in ooze or blue clay.

Previous Known Distribution: Known from type locality and Atka Island in the Bering Sea at 1019 – 3500 m (D'yakonov 1969); also deep off Vancouver Island (Austin 1985).

New Distribution: Austin (1985) mentions occurrence in BC. This study confirms the presence of this species in BC waters from 1625 – 2125 m.

Other References: Agassiz and Clark (1909).

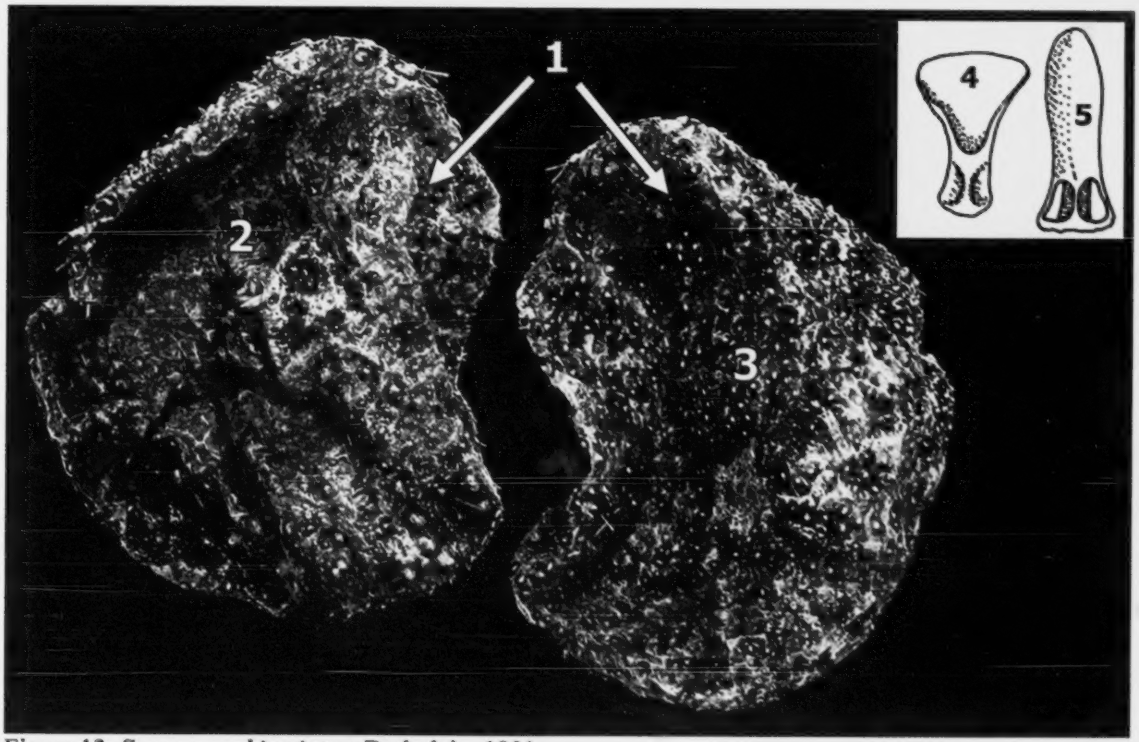


Figure 13. *Sperosoma biseriatum* Doderlein, 1901.

Sperosoma giganteum Agassiz and Clark, 1907

Diagnostic Characters: Up to 32 cm in diameter; deep purple almost black; no primary spines on the aboral surface but lots of secondary and smaller spines; primary spines on the oral surface are numerous but irregularly spaced and often terminate in a white hoof-shaped tip; tridentate pedicellariae similar to *S. biseriatum* (Figure 13) but also triphyllous and **ophicephalous pedicellariae (1),** the latter confined to the ambitus (the edge where the aboral surface becomes the oral).

Material Examined: None collected in this study.

Type Locality: Station 5082, off Omai Saki Light, Honshu Island, Japan, 662 fathoms (Agassiz and Clark 1907).

Previous Known Distribution: Type locality off Japan, and off Oregon, 2090 – 3000 m (McCauley and Carey 1967).

Remarks: The specimens collected by McCauley were all smaller than the type (320 mm diameter) at 112 – 160 mm. Perhaps they were misidentified and are the smaller *S. biseriatum.*

Other References : Agassiz and Clark (1909).

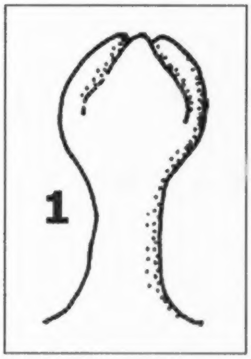


Figure 14. Ophicephalous pedicellariae of *Sperosoma giganteum* Agassiz and Clark, 1907

Order Holasteroida
Family Urechinidae

Cystechinus loveni Agassiz, 1898

Pyramid Sea Urchin

Synonyms: ***Urechinus loveni*** **(Agassiz, 1898)**

Diagnostic Characters: No anal snout; **periproct not in a depression (1)**; large forms. Test not high, not flexible. Valves of globiferous pedicellariae terminating in two or more hooks. A **rounded pyramid shape (2)**, colour of test deep reddish purple, but can be rubbed off.

Material Examined: None collected in this study.

Type Locality: Albatross 3415, south of Punta Maldonado, Guerrero, Mexico (14° 46' 00"N 98° 40' 00" W), 1879 fms (3436 m), brown mud and globigerina ooze.

Known Distribution: Bering Sea to Mexico (Agassiz and Clark 1907); off Magdalena Bay, Baja California, 3219 m (H.L. Clark 1913); Northern Pacific, Acapulco and Lower California to Bering Sea and Ochotsk Sea, 3070 – 3610 m (Mortensen 1950); off Oregon, 2600 – 2833 m in green gray mud (McCauley and Carey 1967); USNM collection, Atka I to NW Channel Islands, California, 3230 – 4080 m (information provided with the permission of the National Museum of Natural History, Smithsonian Institution, 10th and Constitution Ave. N.W., Washington, DC 20560-0193: http://www.nmnh.si.edu/).

Remarks: Not collected in BC yet, but occurs to the north and south; therefore, would be expected here in deep water. Originally described as a member of the genus *Cystechinus, U. loveni* was moved to *Urechinus* by Mortensen (1907); however, Mooi and David (1996) re-analysed all the species of *Urechinus* and found that three species clustered together separately from the other *Urechinus* and they re-assigned them back to *Cystechinus*.

Other references: Agassiz (1904).

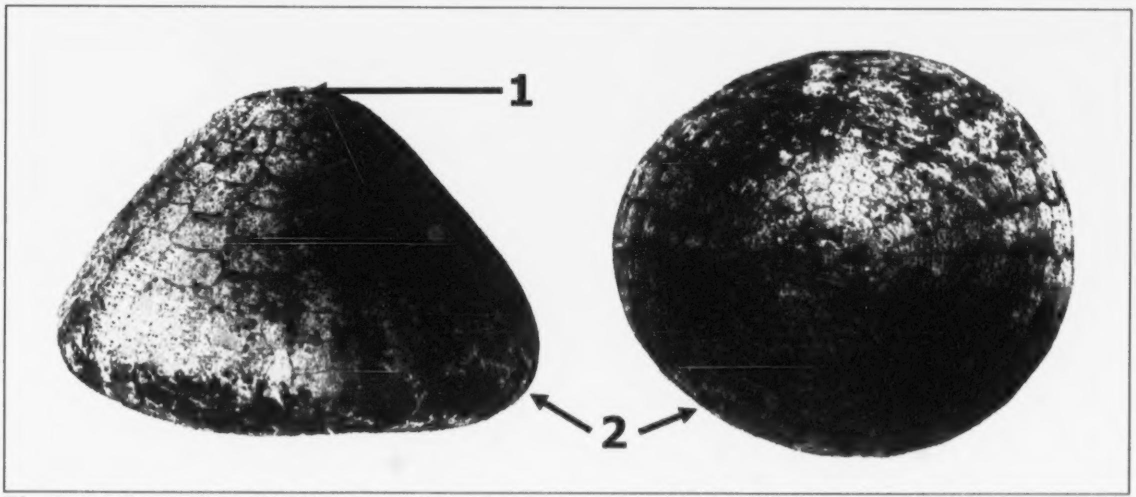


Figure 15. Pyramid Sea Urchin, *Cystechinus loveni* Agassiz, 1898. Image after Agassiz (1898).

Family Pourtalesiidae (Deep-sea Urchins)

Ceratophysa ceratopyga valvaecristata Mironov, 1976

Diagnostic Characters: Large test over 80 mm in length; **triangular in outline (1)**; thin shelled. Strongly developed **subanal rostrum (2)** with parallel oral and anal surfaces; rostrum gradually narrows posteriorly. Tridentate pedicellariae have a prominent tooth-like projection on the outside of each valve.

Material Examined: None collected in this study.

Type Locality: Vityaz 3575, NE Pacific Ocean (38° 02`N, 146° 33`W), 5495 m.

Known Distribution: Northern Pacific, from Japan to Alaska, and off California, 4200 – 6320 m (Mironov 1976).

Remarks: This species occurs in deeper water than sampled in this study.

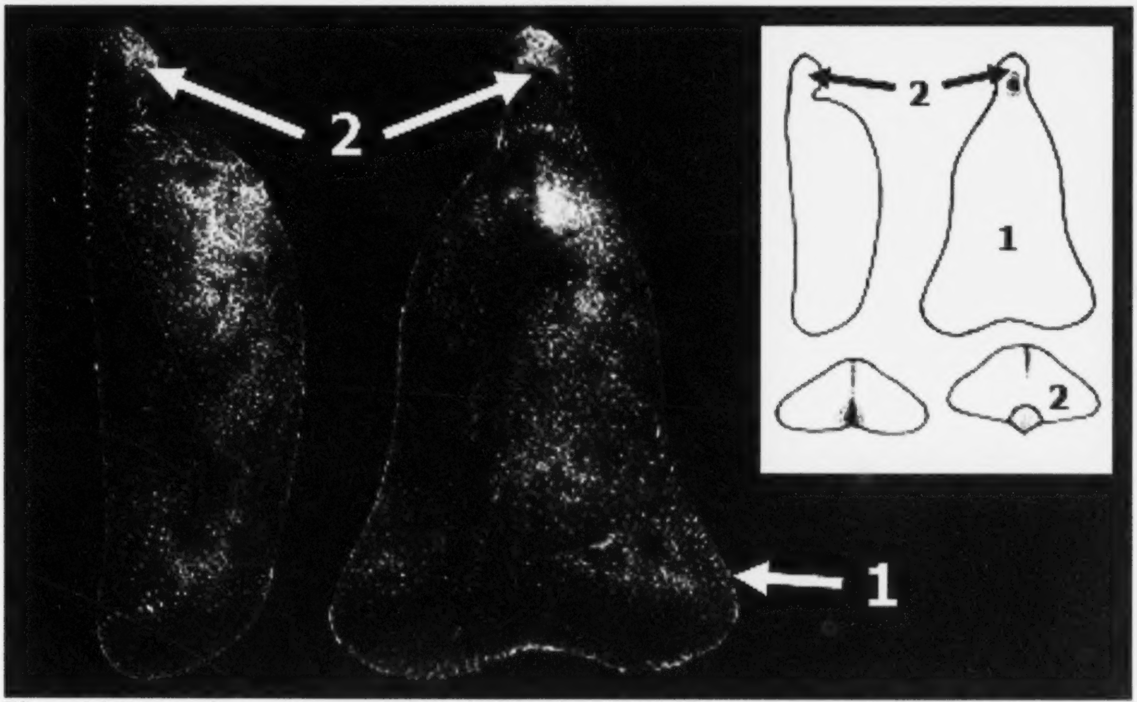


Figure 16. *Ceratophysa ceratopyga*, a closely related species to *C. ceratopyga valvaecristata*. Images after Agassiz (1881).

Cystocrepis setigera (Agassiz, 1898)

Synonyms: *Echinocrepis setigera* Agassiz

Diagnostic Characters: Elongate oval up to 99 mm long and 51 mm wide; Elongation of the odd interambulacrum (posterior part). Less angular than *E. cuneata* (Figure 18). Actinal system protected by five large plates. Long primary spines all over the **aboral side (1)** . Tridentate, rostrate, and ophicephalous pedicellariae. Bivial ambulacra discontinuous. **Anterior extremity barely indented (2)**. Test, chocolate colour or sometimes deep claret; primary spines (20 to 22 mm long) are pinkish.

Material Examined: None collected in this study.

Type Locality: Albatross 3399, off Galera Point, Ecuador (1° 7' N 81° 4' W), 1740 fms (3182 m), green ooze.

Known Distribution: Panamic Region, 2875 – 3435 m off Mexico and Panama (Lessios 2005).

Remarks: Not yet found in BC

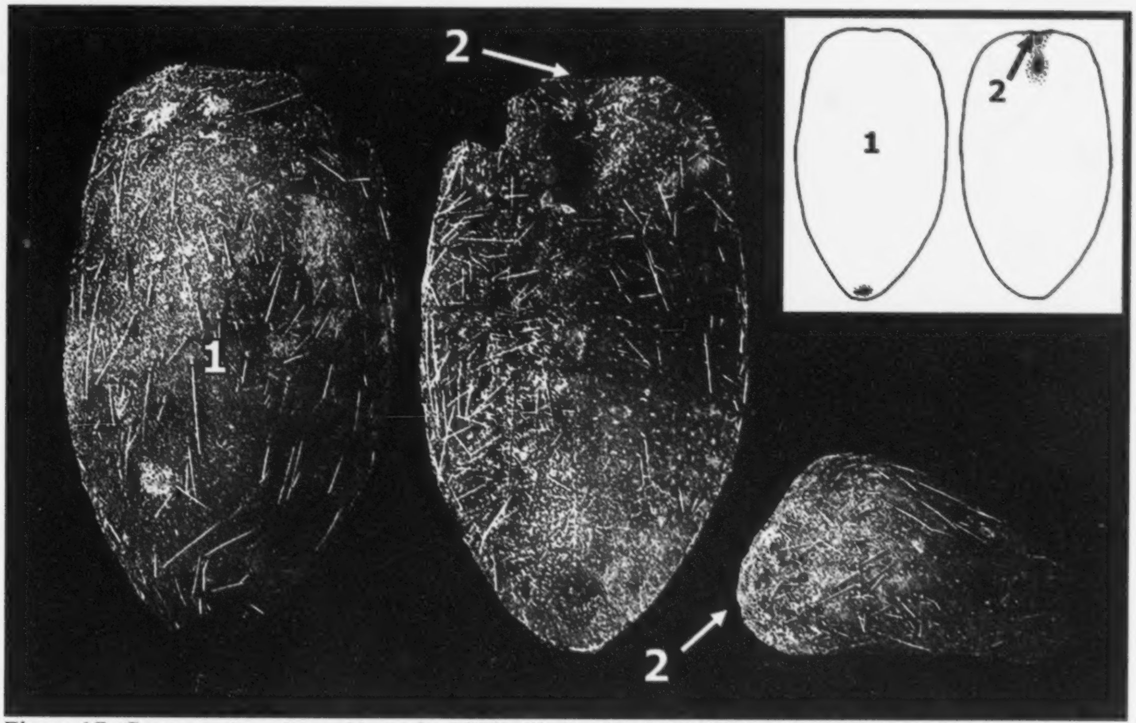


Figure 17. *Cystocrepis setigera* (Agassiz, 1898). Photos (Smith 2005b). Line drawing after Agassiz (1904).

Echinocrepis rostrata Mironov, 1973

Diagnostic Characters: Triangular or arrowhead-shaped sea urchin. Large (86 – 108 mm long) urchin with small **sub-anal rostrum (1)**. **Four genital pores (2)**. Primary spines are numerous and small; straight on the aboral surface, thicker on the **oral surface (3)**. The ophicephalous pedicellariae have a wide base and narrow distal jaw.

Material Examined: None collected in this study.

Type Locality: Vityaz 4213, off southern California (34° 54`N, 143° 59`W), 4200 – 4231 m.

Known Distribution: Aleutian Trench to Baja California. 3315 – 5020 m (Mironov 1973).

Remarks: One record off BC at 3470 m (Vityaz 4147 of Mironov 1973). Our sampling was probably not deep enough for this species. ***Echinocrepis cuneata*** **(c)** is a closely related species.

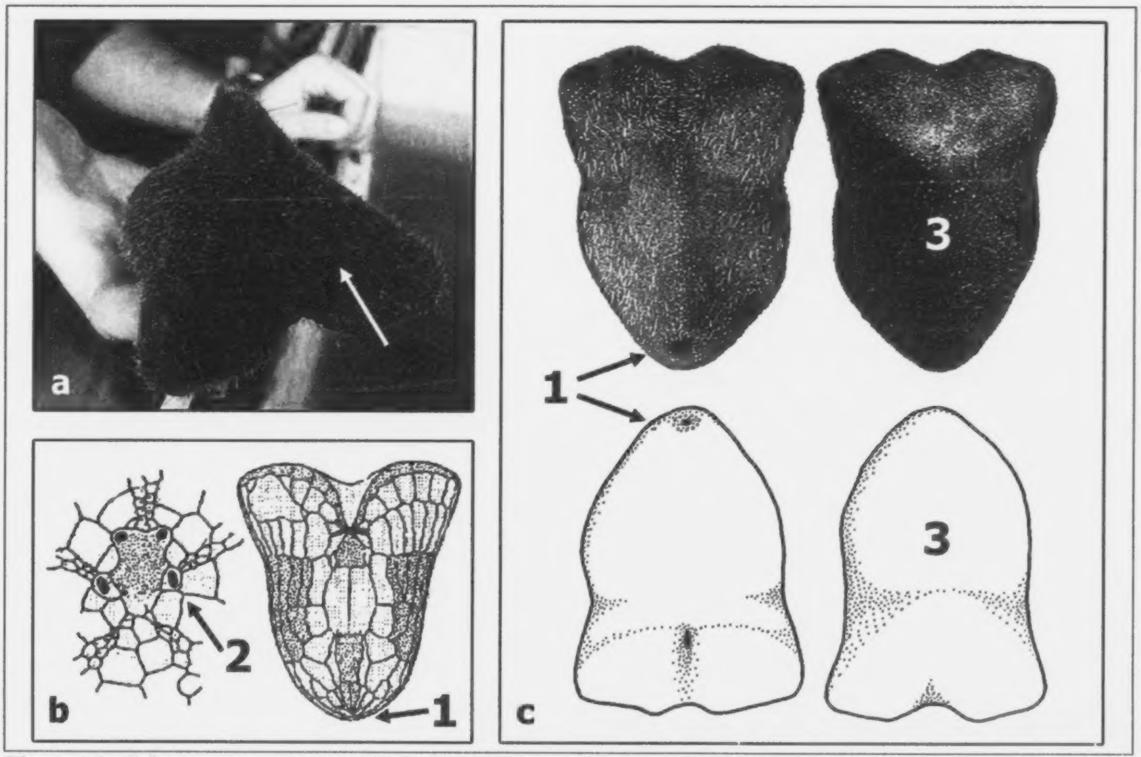


Figure 18. *Echinocrepis rostrata* Mironov, 1973, a) courtesy P. McGill, MBARI and b) after Mironov (1973); c) *E. cuneata*, a closely related species (after Agassiz 1881).

Pourtalesia tanneri **Agassiz, 1898**

Diagnostic Characters: Closely related to ***Pourtalesia laguncula*** **(1)** but more elongate, less **bottle-shaped (2)** . Less than 20 mm long. Length to width ratio at least 2. **Aboral surface (3)** slightly convex; **oral side (4)** is somewhat flat. The anterior extremity of the test is higher; the posterior portion of the test drops abruptly to a prominent posterior rostrum. The larger primary tubercles are concentrated on the sides of the test in a triangular space. Spines are pointed. Rostral pedicellariae have narrow valves. In small individuals (12 mm) the test is more pointed posteriorly and the proboscis less developed. Colour of the test bright pink or purple with violet tinge around the base of the primary tubercles.

Material Examined: None collected in this study.

Type Locality: Albatross 3411, between Bindloe and Wenham Islands, Galapagos Islands (0° 54' N 91° 9' W), 1189 fms (2174 m), yellow globigerina ooze.

Previous Known Distribution: Gulf of California to Galapagos and Chile, 1450 – 2380 m (Mortensen 1950); California to Peru, also possibly Gulf of Alaska and in the Bering Sea near the Aleutians, 1820 – 3954 m (Mironov 1976).

Remarks: Potentially in deep water off BC but not yet reported.

Other References: Loven (1883).

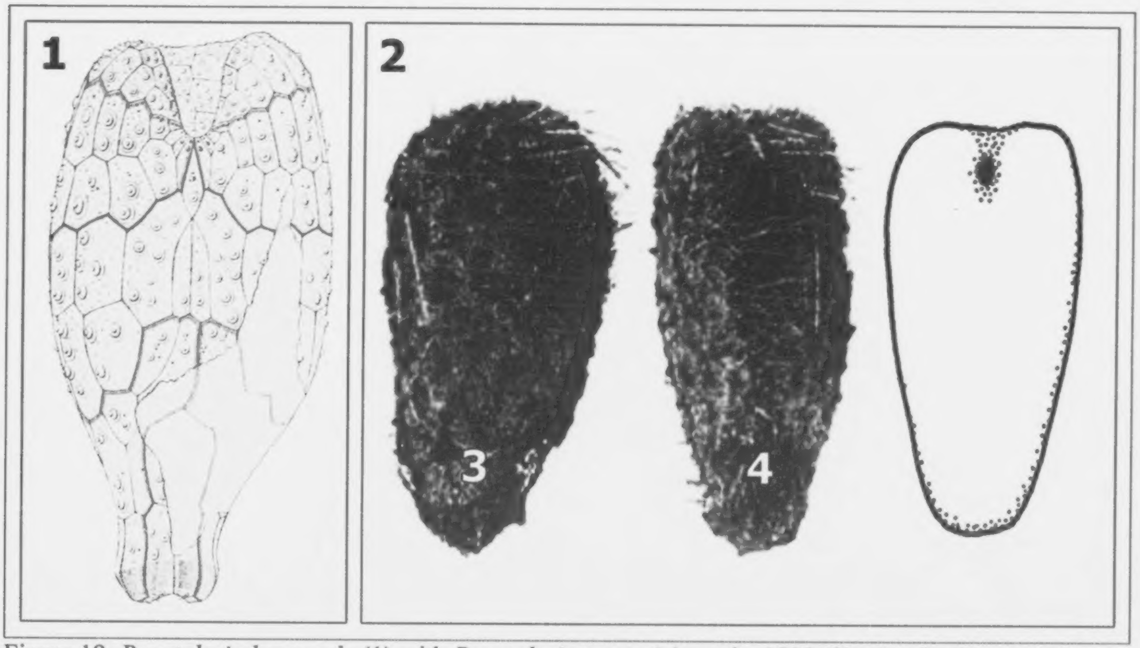


Figure 19. *Pourtalesia laguncula* (1) with *Pourtalesia tanneri* Agassiz, 1898 (2); (1) after Loven 1883; (2) after Agassiz 1898.

Pourtalesia thomsoni Mironov, 1976

Diagnostic Characters: Length of bottle-shaped test, up to 28 mm (longest of all the species in genus *Pourtalesia*); width to length ratio 0.36. **Anterior portion (1)** of test is convex; aboral surface is concave (when viewed from the side). Test drops vertically to the **rostrum (2)**. Spines are pointed. Rostral pedicellariae have narrow valves; ophicephalous pedicellariae have 6 – 10 large tooth-like projections. Light gray test.

Material Examined: None collected in this study.

Type Locality: Vityaz 4265, off Baja California (24° 57' N, 113° 24' W), 3315 – 3340 m.

Known Distribution: Northern Pacific, from Alaska to California, 3315 – 4321 m (Mironov 1976).

Remarks: Potentially could occur off BC. Similar general shape to *P. jeffreysi* but with above noted differences.

Other References: Smith (2005).

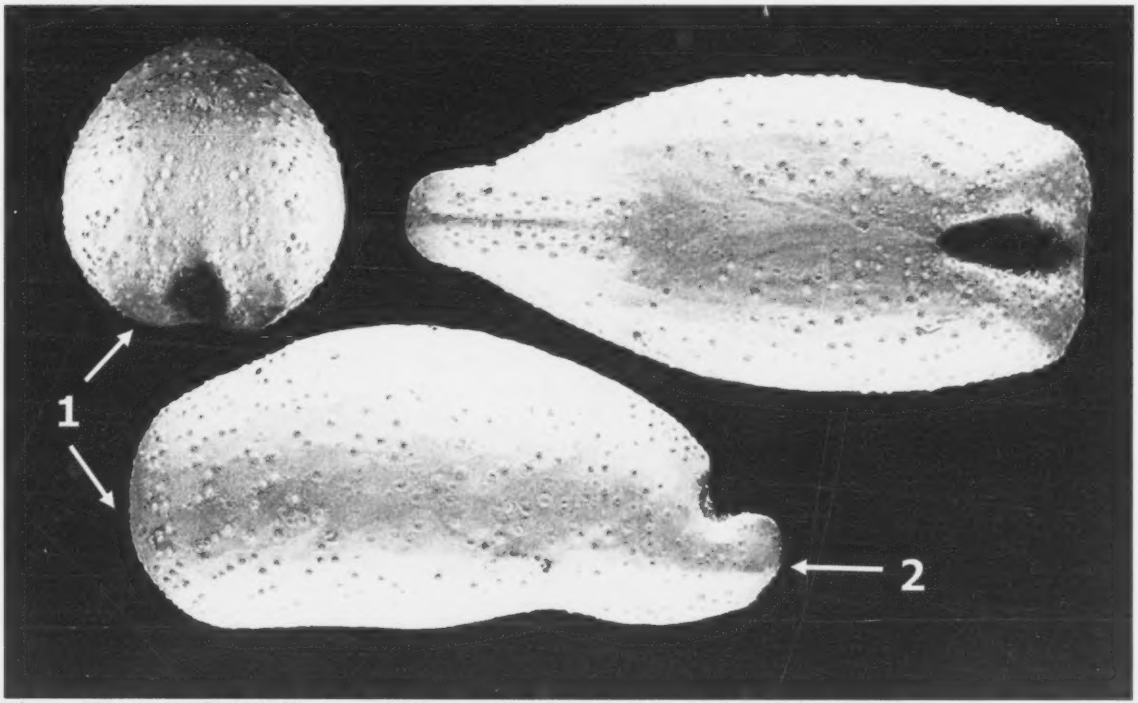


Figure 20. *Pourtalesia jeffreysi*, a similar species to *P. thomsoni* (after Smith 2005b).

Order Spatangoida
Family Aeropsidae

Aeropsis fulva **(Agassiz, 1898)**
Oblong Heart Urchin

Synonyms: *Aërope fulva* Agassiz, 1898

Diagnostic Characters: Test cylindrical and twice as long as wide, tapering to a pointed anal rostrum at the posterior end; with a lateral flattening of the test. Slit-shaped **mouth (1)** situated in anterior third of body and **anus (2)** near posterior end of test; maximum length 50 mm. Large podia with suckers confined to the upper part of the anterior radius. Primary tuberculation is uniform over the test and primary spines slender in comparison with stouter spines of *A. rostrata*. Live animals, dark yellowish brown.

Material Examined: None collected in this study.

Type Locality: Agassiz did not designate a type locality but all 5 Albatross stations were between northern Ecuador and Cost Rica, 1175-1772 fms (2149 – 3181 m).

Previous Known Distribution: Off Costa Rica, Columbia and Ecuador, 2149 – 3241 m (Agassiz 1904); Bering Sea, off Oregon, coast of Peru, Columbia and Malay archipelago, 2148 – 5200 m (McCauley and Carey 1967); Japan, Bering Sea, Gulf of Alaska, off BC, Gulf of Panama, 1463 – 5390 m (Mironov 1976); 1465 – 5200 m (Mortensen 1950).

Remarks: Due to its wide range, it is possible off BC at appropriate depths.

Other References: Agassiz and Clark (1907), McCauley and Carey (1967).

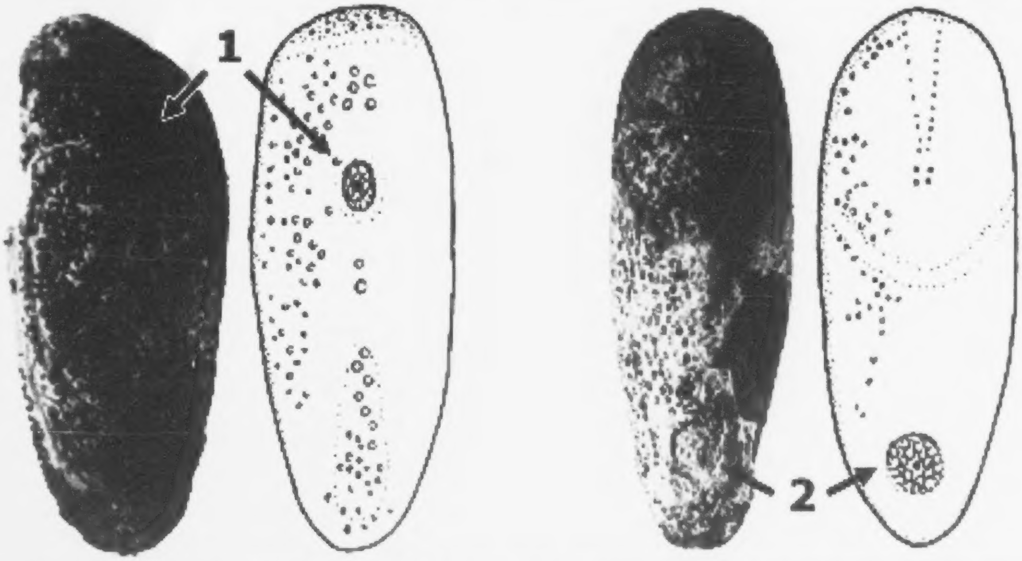


Figure 21. Oblong Heart Urchin, *Aeropsis fulva* (Agassiz, 1898). Photos after Agassiz (1898); line drawings after Smith et al. (2005).

CLASS OPHIUROIDEA: Basket Stars and Brittle Stars

Key to Families of Brittle Stars (Ophiuroidea) of British Columbia, Canada and Southeast Alaska adapted from Fell (1960). This is a general key to the families of ophiuroids but not all these families are encountered in BC. See Figure 22 and Figure 23 for ophiuroid anatomy and representative features, and consult Lambert and Austin (2007) for further information. See page 139 for a glossary of terms.

1a Disk and arms covered by thick skin which may contain granules but does not cover plates or scales. Arm spines point downwards. 2
1b Disk and arms covered by scales or plates (may be covered by skin). Arm spines placed laterally 4

2a Hooks on aboral side of arms, arms forked, disk and arms bearing only small spinules or granules or else naked .... Gorgonocephalidae
2b No hooks on aboral side of arms; at distal end of arms, lateral arm spines are transformed into hooks which lack perforations 3

3a Gonads restricted to disk; disk, aboral surface, and radial shields are not granulated, arms long and whip-like, more than three arm spines per joint. .... Asteronychidae
3b Gonads extending to at least midway along arms; disk, aboral surface and radial shields are granulated. Two arm spines per joint. .... Asteroschematidae (p.38)

4a Thick, soft skin covers the plates of disk and arms but underlying plates and scales visible after drying; arm spines rough at tip; arms capable of rolling into vertical coils. ... Ophiomyxidae (p.39)
4b Disk and arms not covered by thick skin; scales and plates easily visible although they may be partly concealed by spines or granules 5

5a Small, spinelike tooth papillae forming a cluster at the apex of each jaw deeper in the mouth; oral papillae may or may not be present 6
5b No cluster of tooth papillae, just regular teeth and oral papillae 7

6a Oral papillae border each jaw, accessory plates do not surround aboral arm shields, lower arm spines distally on arms not hooked .... Ophiocomidae
6b No oral papillae, a hole present at the base of the jaw pieces. .... Ophiothricidae

7a Paired papillae at apex of jaw (except Amphilepis) .... Amphiuridae (p.53)
7b An unpaired papilla at the apex of each jaw 8

8a Arms inserted laterally and firmly attached to the disk or fused in a notch (e.g. Ophiura) 9
8b Arms inserted under the disk and not firmly fused; disk overhanging the arms and may easily detach from skeleton 10

9a Granules cover the disk scales of upper and lower surfaces, often also on jaws ... Ophiodermatidae
9b No granules on plates .... Ophiuridae (p. 45) and Ophiolepididae (p.55)

10a Margin of jaws bear uniform (in varying numbers) oral papillae along the side of the oral plate 11
10b Oral papillae not in a continuous, uniform series; often there is a space between lateral oral papillae and infradental papillae at apex of oral plates; dissimilar papillae .... Ophiactidae

11a No granules or spinules on disk 12

11b Granules or spinules on disk; arms slender, often constricted between each arm joint producing a scalloped look.......... 13

12a Arms robust, not constricted; a keel on the midline of each oral arm-plate; disk large and flat.......... Ophiochitonidae

12b Arms slender, elongated without oral or aboral keels.......... Amphilepidinae (subfamily of Amphiuridae, p. 54)

13a Arm spines numerous, long, conspicuous, erect.......... Ophiacanthidae p.40

13b Few small, inconspicuous arm spines.......... Ophioleucidae

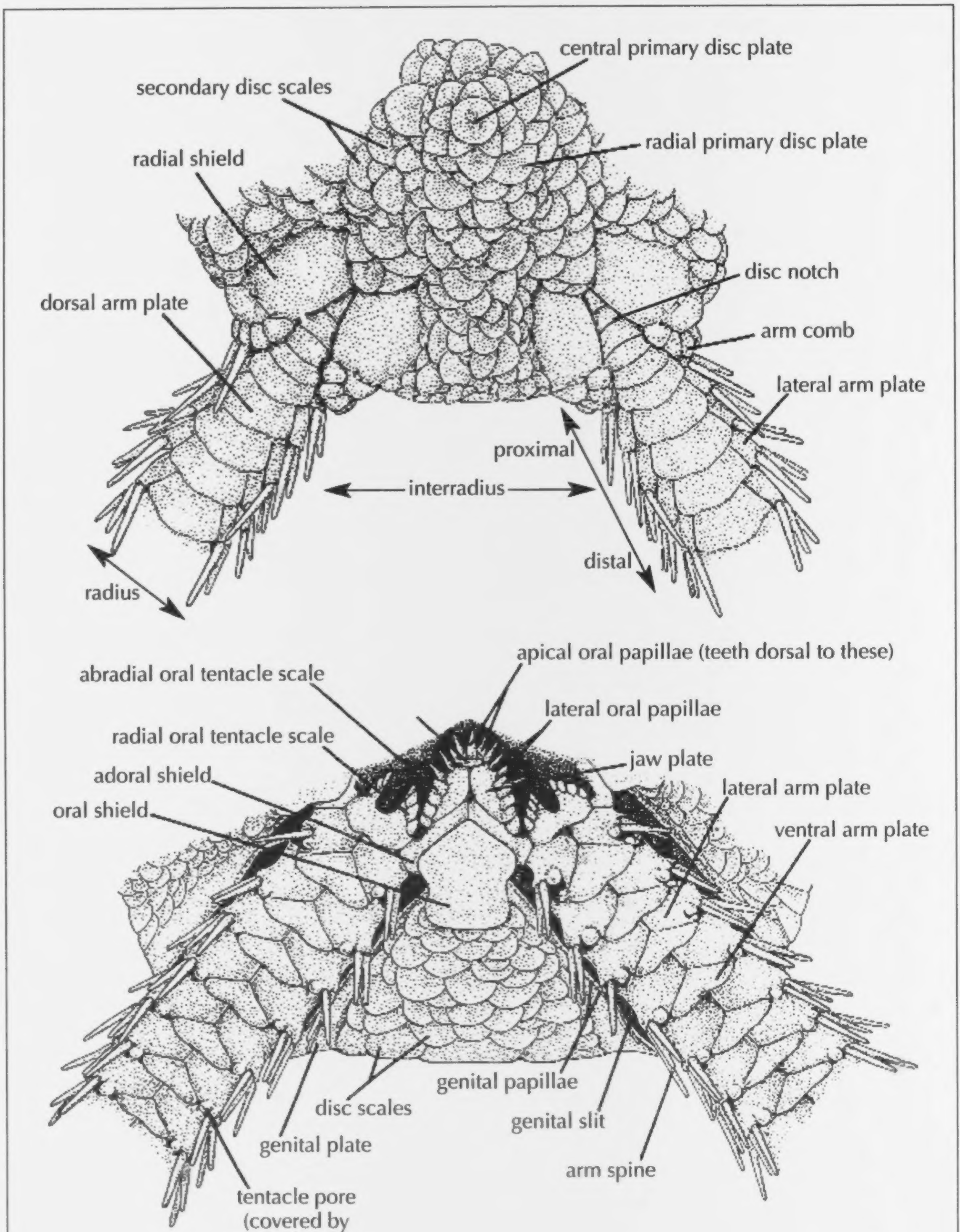

central primary disc plate
secondary disc scales
radial primary disc plate
radial shield
disc notch
dorsal arm plate
arm comb
lateral arm plate
proximal
interradius
distal
radius
apical oral papillae (teeth dorsal to these)
abradial oral tentacle scale
lateral oral papillae
radial oral tentacle scale
jaw plate
adoral shield
lateral arm plate
oral shield
ventral arm plate
genital papillae
disc scales
genital slit
genital plate
arm spine
tentacle pore
(covered by
tentacle scale)

Figure 22. Ophiuroid anatomy (Lambert and Austin 2007).

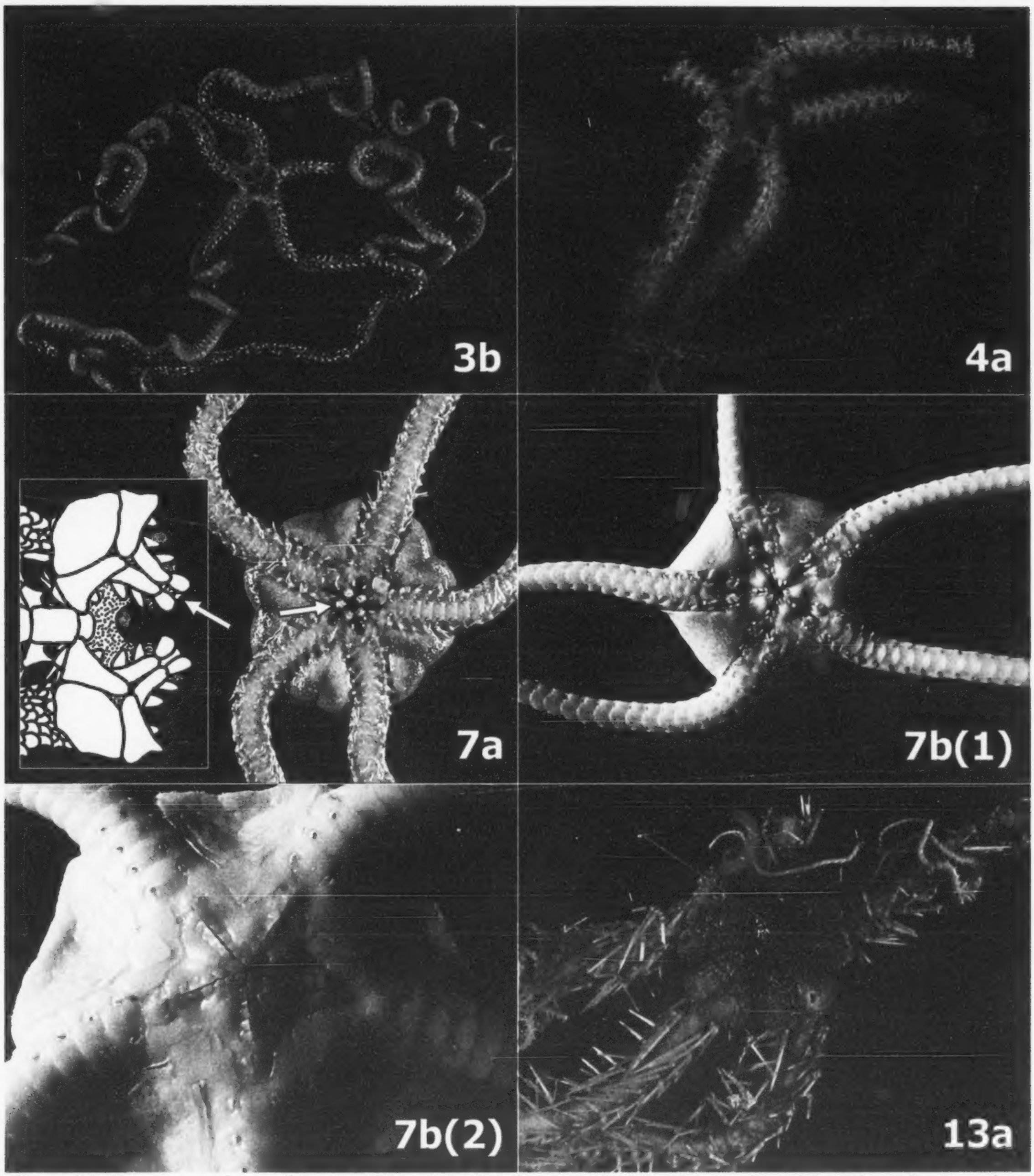
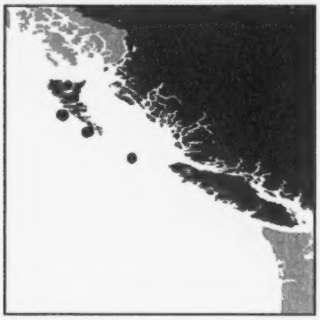

3b
4a
7a
7b(1)
7b(2)
13a

Figure 23. Representatives of the families of the brittle stars (Ophiuroidea) of British Columbia, Canada.. Labels refer to the key.



Subclass Ophiuridea
Order Euryalida
Family Asteroschematidae

Asteroschema sublaeve Lütken and Mortensen, 1899

Diagnostic Characters: **Disk (1)** 5 mm diam. **Arms (2)** about 300 mm long. **Mouth (3)** has 8 – 9 rounded teeth; sides and **aboral side of arms and disk (4)** covered with round, rough grains of different sizes. Ribs on the disk covered with large grains, spaces between, covered sparingly with smaller grains. The first two tentacle pores have no scales; at the third, one or two, and from the fourth, two sometimes three. The inner tentacle scale as long as two segments, club-shaped, enclosed in thick skin.

Material Examined: Sixteen specimens in six lots from 918 – 1909 m between northern tip of Vancouver Island and Englefield Bay, Haida Gwaii.

Type Locality: Not designated in the original description but a series of syntypes was deposited at the Smithsonian from five stations between Panama and Cocos Island. The first of these was Albatross 3353 off Panama (7° 6' 15" N 80° 34' W), 695 fms (1271 m), green mud.

Previous Known Distribution: Panama to tip of Baja California, 605 – 1681 m (Lütken and Mortensen 1899); off BC, 49° 12' N, 1280 m (Austin and Haylock 1973).

New Distribution: Panama to Englefield Bay, Haida Gwaii, 605 – 1909 m.

Remarks: This study extends the known range from lower Vancouver Island to Haida Gwaii, and extends the maximum depth. Note that many references spell the genus as *Astroschema* following the original description; however, the genus to which it belongs was first described by Ljungman (1872) and spelled *Asteroschema.*

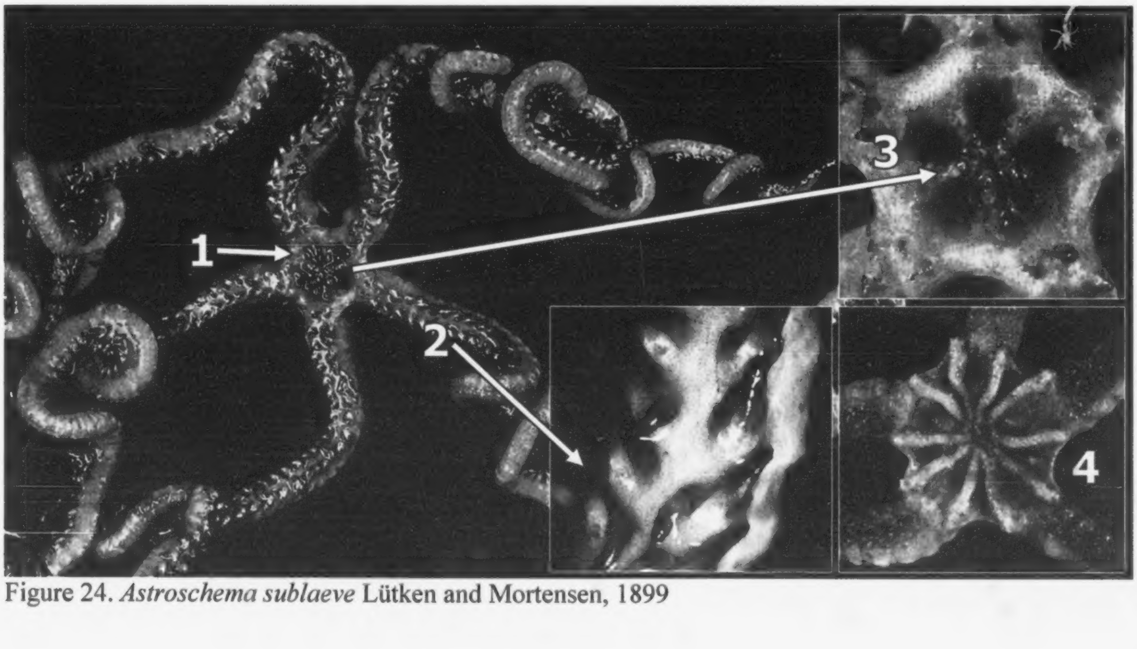
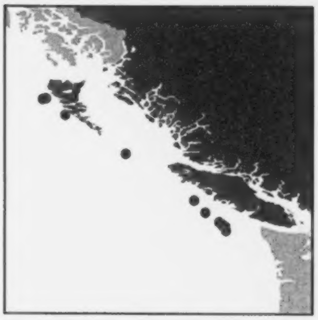


Figure 24. *Astroschema sublaeve* Lütken and Mortensen, 1899



Order Ophiurida (Brittle Stars)

Suborder Ophiomyxina
Family Ophiomyxidae

Ophioscolex corynetes (H.L. Clark, 1911)
Fleshy Brittle Star

Synonyms: *Ophiocynodus corynetes* H.L. Clark

Diagnostic Characters: **Disk (1)** covered with naked skin, but often **torn off (2)** ; usually red in colour; **no radial shields (3)**, upper arm plates or tentacle scales. **Oral papillae (4)** all alike, spiniform and rough at the tip. Side arm plates small, each with **three sub-equal spines (5)**, nearly equal to two segments; lowest with marked swelling at the tip. Tentacle pores large but no tentacle scales.

Material Examined: Sixty-one specimens in twelve lots from 538 – 1220 m between Barkley Sound and Rennell Sound, Haida Gwaii.

Type Locality: Albatross 3347, off Oregon (45° 9' 35" N, 124° 45' 00" W), 345 fms (631 m), mud.

Previous Known Distribution: California, Oregon, Washington, 549 – 1253 m (Astrahantseff and Alton 1965); off Washington 45°29'N to 47°29'N, 631 – 1253 m; off Cape Flattery north to Queen Charlotte Sound, 549 – 924 m (Austin and Haylock 1973).

New Distribution: California to Haida Gwaii; 538 – 1253 m.

Remarks: This study extends the known northern limit from Queen Charlotte Sound to Englefield Bay, Haida Gwaii.

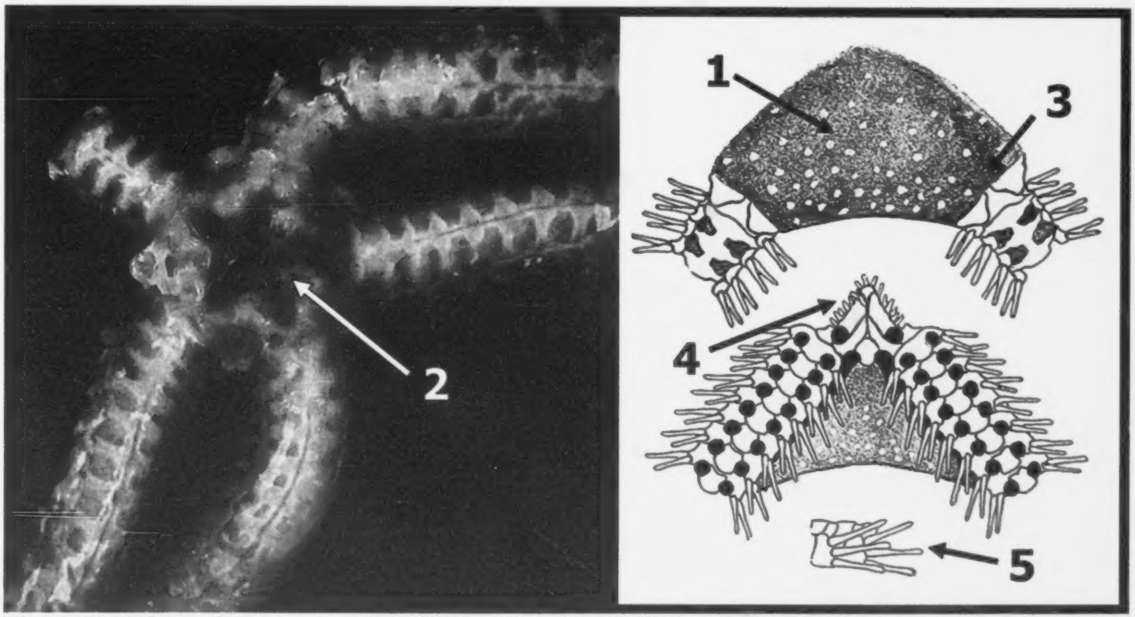


Figure 25 *Ophioscolex corynetes* H.L. Clark, 1911. Drawing after H.L. Clark (1911).

Suborder Ophiurina
Family Ophiacanthidae

Ophiacantha bathybia H.L. Clark, 1911

Diagnostic Characters: Disk more or less pentagonal **covered with minute thorny stumps (1)**; **radial shields (2)** concealed but positions indicated in dry specimens (long narrow and well separated). Upper arm plates rounded, triangular, tending to rhombic. **Side arm plates with 6 slender, sharp spines (3)**, the uppermost longest and about three segments in length. Tentacle scales single, small and sharp.

Material Examined: None collected in this study.

Type Locality: Albatross 2859, west of Prince of Wales Island, Alaska (55°20`N, 136°20`W), 1569 fms (2869 m), gray ooze.

Known Distribution: BC to the Bering Sea, 1602 – 3608 m (H.L. Clark 1911); off Baja California, 1587 – 1993 m (H.L. Clark 1920); California to Japan trench, 1590 – 6450 m (Imaoka et al. 1991).

Remarks: Not collected during this study but has been recorded in BC waters.

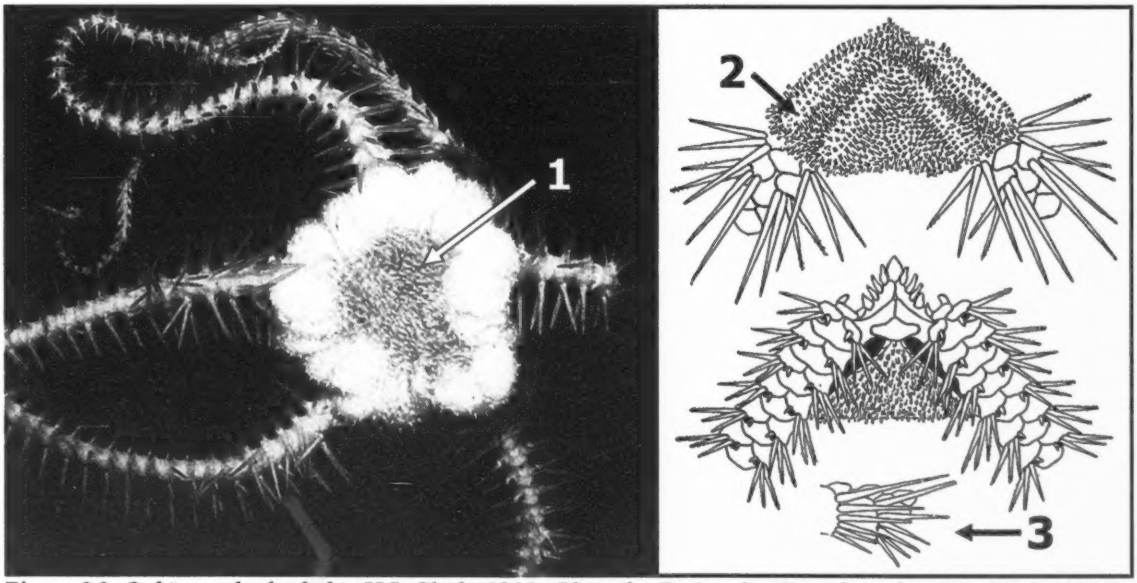
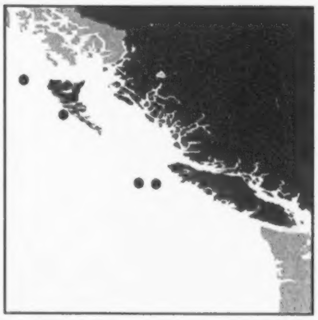


Figure 26. *Ophiacantha bathybia* H.L Clark, 1911. Photo by B. Austin. Drawing after H.L Clark (1911).



Ophiacantha eurypoma H.L. Clark, 1911

Diagnostic Characters: **Disk covered with very minute thorny stumps (1)** (not granules) which are often rubbed off. **Radial shields (2)** roundish, bare, almost touching distally. **Oral papillae (3)** three to a side and one at apex of jaw; all are long, narrow and sharp except the outermost which is wide and squarish. **Seven or eight slender arm spines (4)**, spine next to uppermost is longest, and equal to about 2 segments. Single large tentacle scale.

Material Examined: Twenty-seven specimens in four lots from 1394 – 2025 m between Quatsino Sound, and Dixon Entrance.

Type Locality: Albatross 2859, west of Prince of Wales Island, Alaska (55°20'N, 136°20'W), 1569 fms (2869 m), gray ooze.

Known Distribution: SE Alaska, 2869 m (H.L. Clark 1911) to Monterey Bay, California, 1575 – 1942 m (May 1924).

New Distribution: Monterey Bay, California to Prince of Wales Island, Alaska, 1394 – 2869 m.

Remarks: This study adds many more records of *O. eurypoma* to the region between SE Alaska and Monterey, and reduces the minimum depth to 1394 m.

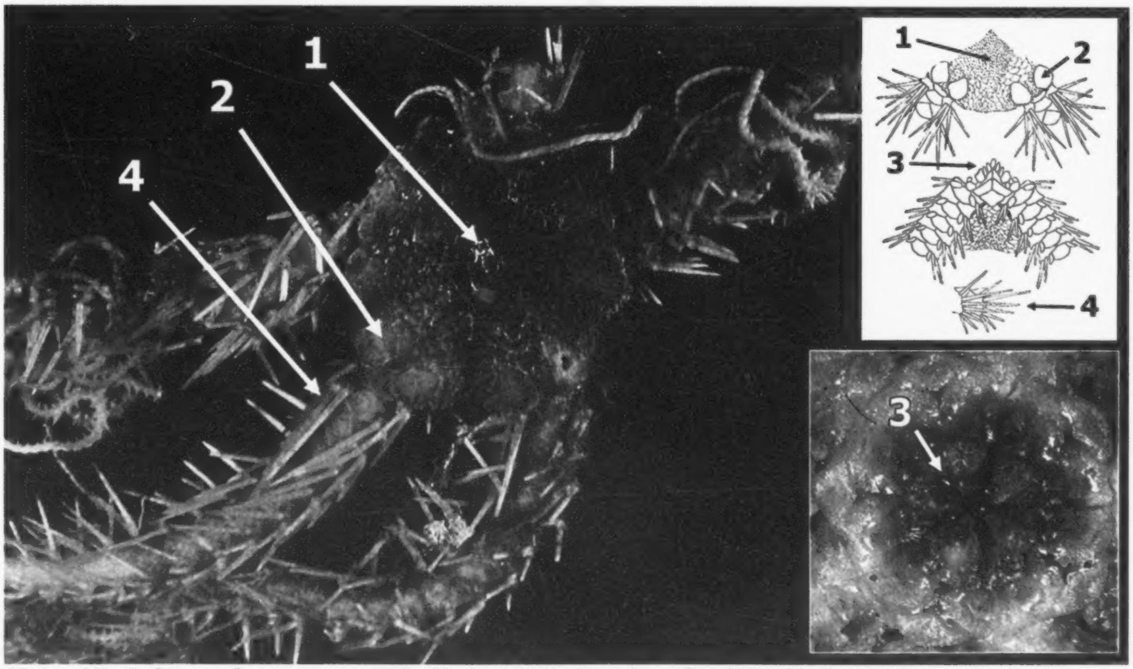
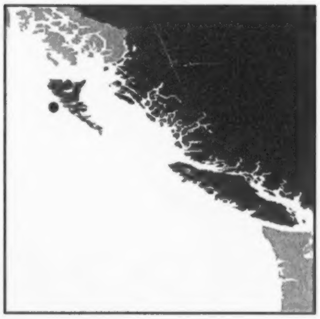


Figure 27. *Ophiacantha eurypoma* H.L Clark, 1911. Drawing after H.L. Clark (1911).



Ophiacantha rhachophora H.L. Clark, 1911

Diagnostic Characters: **Disk (diam. 5 mm) covered with short stumps (1)** which are nearly cylindrical and terminate with two or three diverging teeth. **Radial shields (2)** covered, only distal tips bare. Upper arm plates triangular. Three thorny **oral papillae (3)** per side, and one thorny tentacle scale. Nine **thorny arm spines (4)**, uppermost is the longest; oral shields triangular. The arms are slender and strongly constricted at the nodes (knotty).

Material Examined: Five specimens in two lots from 640 – 1190 m between Triangle Island and off Skidegate Channel tentatively identified as *O. rhachophora.*

Type Locality: Albatross 4902, Goto Islands, Japan (32° 30' 50" N, 128° 34' 40" E), 139 fms (254 m), gray sand.

Previous Known Distribution: Japan to Bering Sea, 115 – 1068 m (H.L. Clark 1911); lower California to the Channel Islands, 825 – 1152 m (H.L. Clark 1913); Cape Flattery to Dixon Entrance, 229 – 1204 m (Austin and Haylock 1973); Sea of Japan, off Kashima to East China Sea, 50 – 1700 m (Imaoka et al. 1991).

New Distribution: If identification is correct, range is extended from Japan to the coast of BC, although H.L Clark (1913) tentatively identified *O. rhachophora* in southern California.

Remarks: Austin and Haylock identified 23 specimens of this species in the waters of BC in 1973; however, Kyte (1977) maintained that *O. rhachophora* was restricted to the waters off Japan. He described those from the Bering Sea as a new species, *Ophiacantha clypeata*. In light of the contradictions in the literature, the specimens identified as *O. rhachophora* and *O. trachybactra* (Figure 29) need further study.

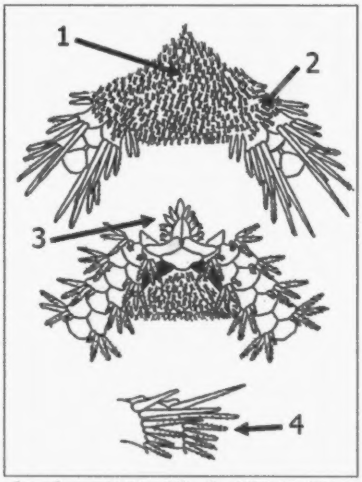
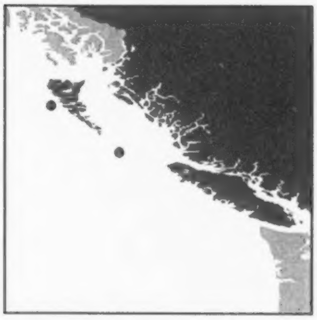


Figure 28. *Ophiacantha rhachophora* H.L. Clark, 1911. Drawing after H.L. Clark (1911).



Ophiacantha trachybactra H.L. Clark, 1911

Diagnostic Characters: **Disk covered by nearly cylindrical stumps (1)** crowned with several minute spinules. Radial shields long, narrow, and well separated, concealed. Oral shield small, somewhat pentagonal but variable. Five or six **oral papillae (2)** on a side, plus one at the apex. Six or seven rather thick **arm spines (3)**, upper ones smooth, lower arm spines, club-shaped and rough. Single, small, pointed tentacle scale.

Material Examined: Nine specimens in two lots from 1240 – 1480 m between Queen Charlotte Sound and Skidegate Channel, Haida Gwaii tentatively identified as *O. trachybactra*.

Type Locality: Albatross 5029, Sea of Okhotsk, Russia (48° 22' 30" N, 145° 43'30"E), 440 fms (805 m), black sand and gravel.

Previous Known Distribution: Alaska Peninsula, Bering Sea and Okhotsk Sea, 805 – 1143 m (H.L. Clark 1911); Alaska to Northern Japan, 800 – 2000 m (Imaoka et al. 1991).

New Distribution: If the identification is correct these data extend the distribution from Alaska south to the north coast of BC.

Remarks: These specimens need further study to confirm the identification before the new distribution can be confirmed.

Other References: Baranova (1955, 1957).

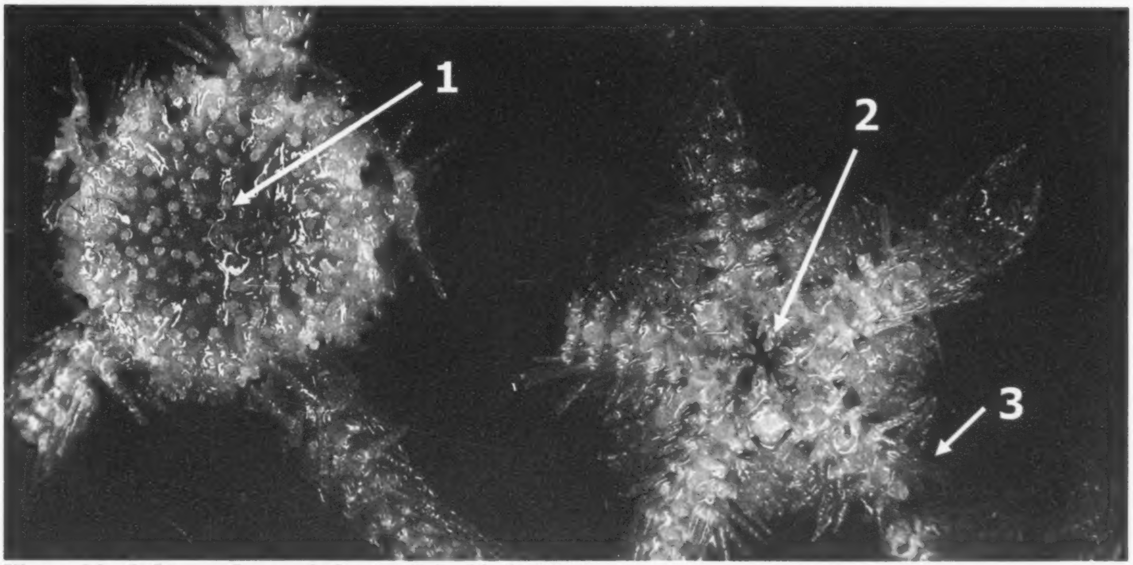
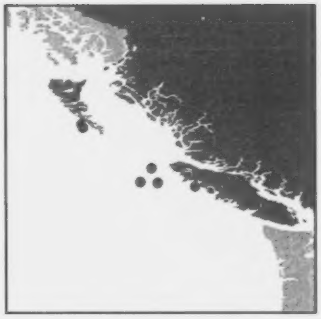


Figure 29. *Ophiacantha trachybactra* H.L. Clark, 1911.



Ophiolimna bairdi (Lyman, 1883)

Synonyms: *Ophiacantha bairdi* Lyman

Diagnostic Characters: Both sides of disk (diam. 10 mm) covered with **granules (1)** concealing the scales. Radial shields short and round and usually hidden beneath a spiny cover. Adoral shields wrap around the oral shield and separate it from the first lateral arm plate. Granules or short spinelets cover the proximal end of the oral and adoral shields. The most distal of the 4 – 6 **oral papillae (2)** is rounded (opercular). 6 – 7 long, pointed, glassy **arm spines (3)**. One large tentacle scale to each pore.

Material Examined: Fifty-one specimens in nine lots from 521 – 2300 m between Vancouver Island and Akutan Island, Aleutians.

Type Locality: Off Maine in the Atlantic Ocean, 2271 m (Lyman 1883).

Previous Known Distribution: Widespread in oceanic waters (Atlantic and Pacific), Sea of Okhotsk, Alaska Peninsula, off Washington State, Panama, Japan, West Indies, Canary Islands, 620 – 2600 m (D'yakonov 1967); widespread in Atlantic and Pacific, 609 – 2600 m (Imaoka et al. 1991); north circumpolar, 914 – 2560 m (Astrahantseff and Alton 1965); Cape Flattery to Dixon Entrance, 924 – 1940 m (Austin and Haylock 1973).

Remarks: Specimens collected in this study are well within the known distribution.

Other References: Baranova (1957), Kyte (1969).

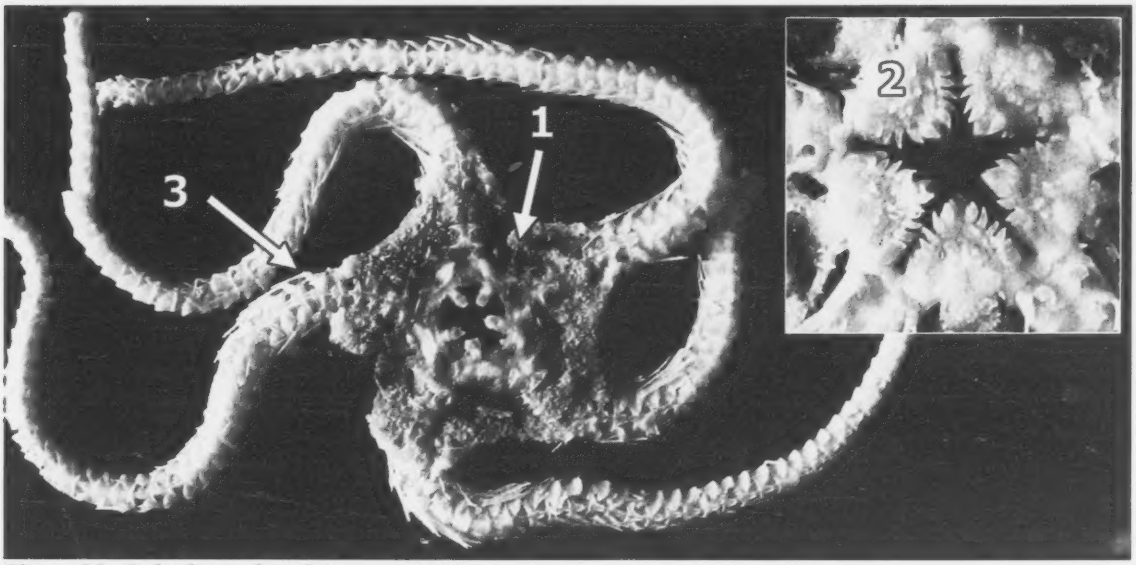


Figure 30. *Ophiolimna bairdi* Lyman, 1883

Infraorder Chilophiurina
Family Ophiuridae
Subfamily Ophiurinae

Amphiophiura bullata pacifica Litvinova, 1971

Diagnostic Characters: Disk (diam 13 mm) (type). Centre of aboral side with a rosette of six primary plates, **a central pentagonal plate surrounded by five hexagonal plates (1)**, usually closely fused. Large **radial shields (2)** slightly longer than wide and separated by a rows of scales, except juveniles are not separated. Arms high and round; arm combs of distinct rounded squarish spinelets. Aboral arm plates inflated; first three wider than long, then hexagonal, and distally becoming triangular. Lateral arm plates inflated and carrying three small, conical arm spines. Five very small conical **oral papillae (3)** on each side of jaw and 2 larger papillae at tip of jaw. **Oral shield (4)** pentagonal and longer than wide.

Material Examined: None collected in this study. Probably did not sample deep enough for this species.

Type Locality: Station 3156, central North Pacific, 39°57'N, 165°03' W, 5535 m (Litvinova 1971).

Previous Known Distribution: North Pacific, off Haida Gwaii, BC to southern Japan; the species occurs between 5027 and 6380 m except for one specimen collected near Haida Gwaii between 2507and 2608 m (Litvinova 1971).

Remarks: This is a subspecies closely related to the Atlantic subspecies *A. bullata bullata*. Arms of this species can only move laterally or down, restricting the species to live or dead prey in or on the substrate. Of stomachs examined, 13 % contained food, including crustaceans, polychaetes, and small bivalves and gastropods as well as a pteropod mollusk (Litvinova and Sokolova 1971).

Other References: Paterson (1985).

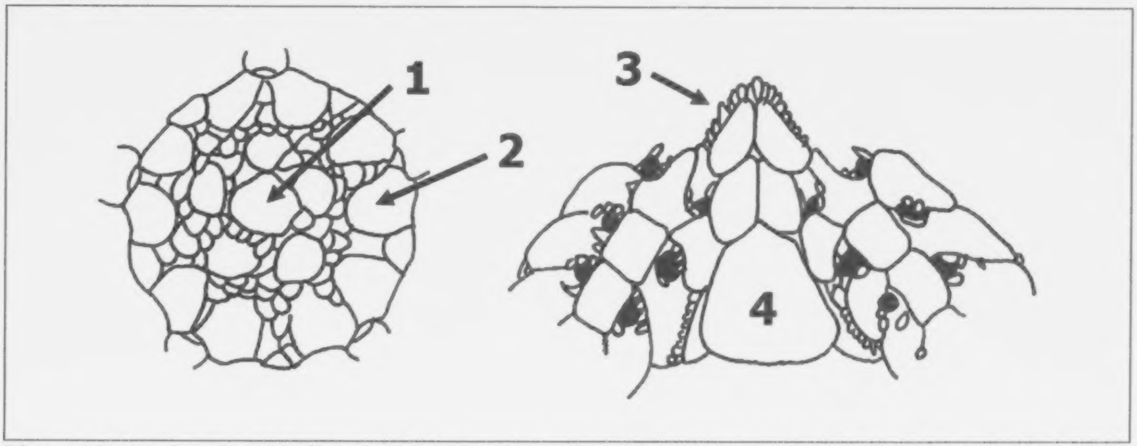
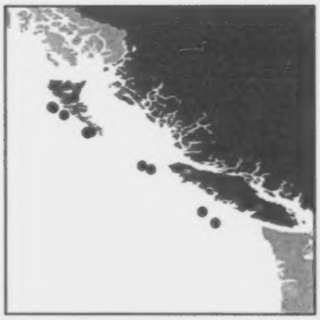


Figure 31. *Amphiophiura bullata bullata*, a similar and closely related species to *A. bullata pacifica*. Drawings after Paterson (1985).



Amphiophiura superba (Lütken and Mortensen, 1899)

Synonyms: Ophioglypha superba Lütken and Mortensen, *Ophiura hadra* H.L. Clark, 1911, *Ophiura superba* Meissner, 1901.

Diagnostic Characters: **Disk covered with thick swollen plates (1)**; **radial shields (2)** large, with a notch at the outer end; shields in contact except at the proximal ends which are separated by an elongate plate. **Well developed arm comb (3)** with short, square close set papillae. Four rudimentary equally spaced **arm spines (4)**, tentacle pores distinct to the end of the arm, numerous tentacle scales (first pair with 5 – 6 on the distal side and 4 or 5 on the proximal) diminishing distally on the arm.

Material Examined: At least 50 specimens in 11 lots from 848 – 1867 m between southern Vancouver Island and off Skidegate Channel, Haida Gwaii.

Type Locality: Albatross 3431, Gulf of California, Mexico (23° 59' N, 108° 40' W), 995 fms (1820 m), light brown mud.

Previous Known Distribution: Gulf of California, Mexico, 1412 – 1820 m (Lütken and Mortensen 1899); Lower California to Monterey, California, 825 – 1701 m (H.L. Clark 1913); Oregon (as *Ophiura hadra*)(Astrahantseff and Alton 1965); Cape Flattery to Dixon Entrance, 1100 – 1537 m (Austin and Haylock 1973).

New Distribution: Gulf of California, Mexico to Dixon Entrance, BC, 825 – 1867 m.

Remarks: This study resulted in a slight increase in the depth range to 1867 m from 1820 m.

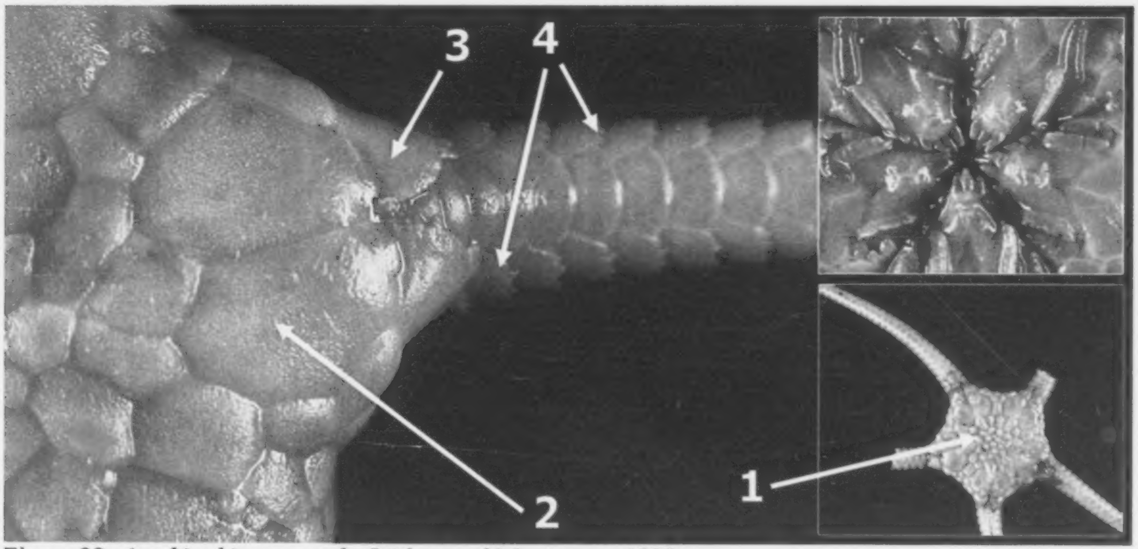
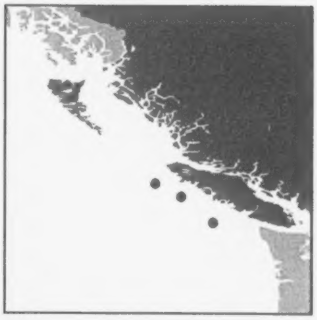


Figure 32. *Amphiophiura superba* Lütken and Mortensen, 1899



Ophiocten hastatum Lyman, 1878

Synonyms: *Ophiocten pacificum* Lütken and Mortensen, 1899

Diagnostic Characters: Arm length five or six times the diameter of the disk. Disk (diam. 9 mm) with minute, thin scales with well-marked primary plates on the aboral surface. Three slender slightly curved **arm spines (1)**, Aboral spine longer than two arm segments, oral spine a little longer than one joint. Four short, close set **oral papillae (2)** on each side, the two outer ones broad. **Oral shield (3)** broader than long. First pair of tentacle pores with two broad scales; second pair of tentacle pores each with a bilobed scale, the remainder with one flat and one minute scale.

Material Examined: Six specimens in three lots from 1574 – 2025 m off southern Vancouver Island and off Cape Scott.

Type Locality: Station 146, off Cape of Good Hope, South Africa.

Known Distribution: Bermuda to Madiera, off Cape of Good Hope to Australia and Phillippines to Japan, 1829 – 2515 m (Lyman 1878); Monterey Bay (May 1924); off Nootka Sound, Vancouver Island to Cape St. James, Haida Gwaii, 1460 – 2200 m (Austin and Haylock 1973); as *O. pacificum*: off Columbia and Panama, 1408 – 2877 m (Lütken and Mortensen 1899); Galapagos Islands and Gulf of Panama to San Diego to 2877 m (McClendon 1909); off BC (Queen Charlotte Sound), Washington and Honshu Island, Japan, 916 – 1602 m (H.L. Clark 1911); off Oregon 1554 – 1920 m (Astrahantseff and Alton 1965).

Remarks: According to May (1924), synonymized with *O. pacificum* by Koehler. Austin (1985) and information obtained from the World Ophiuroidea Database (Stöhr and O' Hara 2007, http://www.marinespecies.org/ophiuroidea/index.php) also indicate the synonymy with *O. pacificum*.

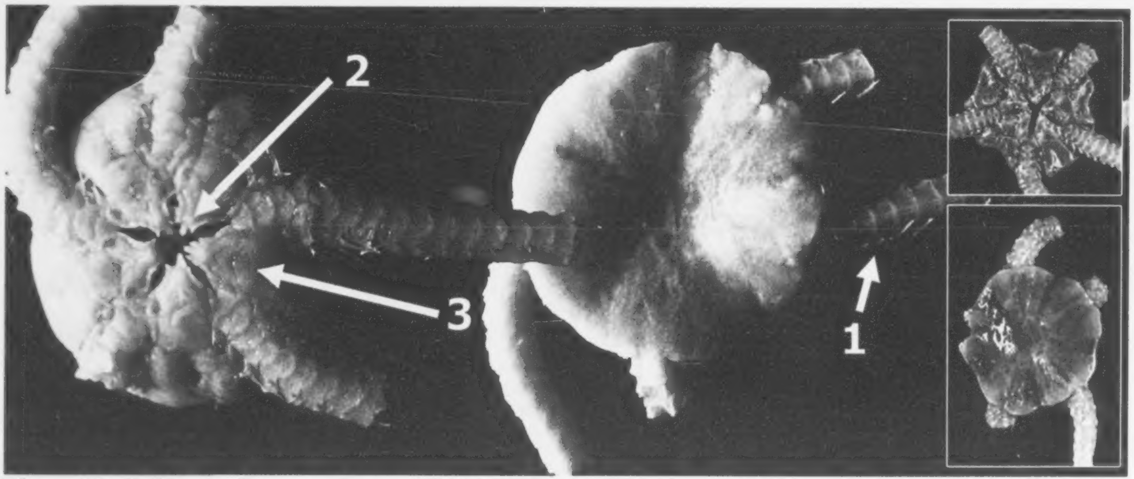
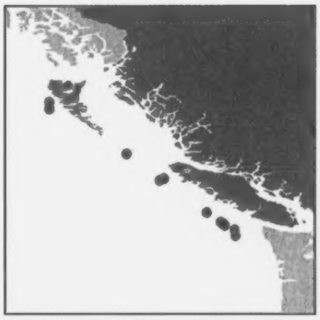


Figure 33. *Ophiocten hastatum* Lyman, 1878



Ophiosphalma jolliense **(McClendon, 1909)**
Tile Brittle Star

Synonyms: *Ophiomusium jolliensis* McClendon, *Ophiomusium jolliense* H.L. Clark 1915

Diagnostic Characters: Disk (diam. < 20 mm), **rounded pentagonal in shape (1)**, central region depressed, margins slightly raised. **Radial shields (2)** approx twice as long as wide and length about ¼ diameter of disk. Aboral arm plates diamond shaped (except first). **Three pairs of tentacle pores (3)** at base of arm. Two or three short blunt arm spines.

Material Examined: At least 120 specimens in 14 lots from 512 – 2105 m between Cape Flattery and west of Rennel Sound, Haida Gwaii.

Type Locality: Off San Diego, California (McClendon 1909).

Previous Known Distribution: Cabo San Lucas, Mexico to Oregon and Japan, 155 – 1463 m (Hendler 1996); Cape Flattery to Queen Charlotte Sound, 428 – 924 m (Austin and Haylock 1973).

New Distribution: Cabo San Lucas, Mexico to Haida Gwaii, BC and Japan, 155 – 1463 m.

Remarks: Fairly common species and often occurs in large numbers when trawled. Hendler (1996) noted that this species was transferred to *Ophiosphalma* because it has three tentacle pores. The correct nominative singular ending for the specific epithet is the neuter form *jolliense*.

Other References: Astrahantseff and Alton (1965), H.L. Clark (1911).

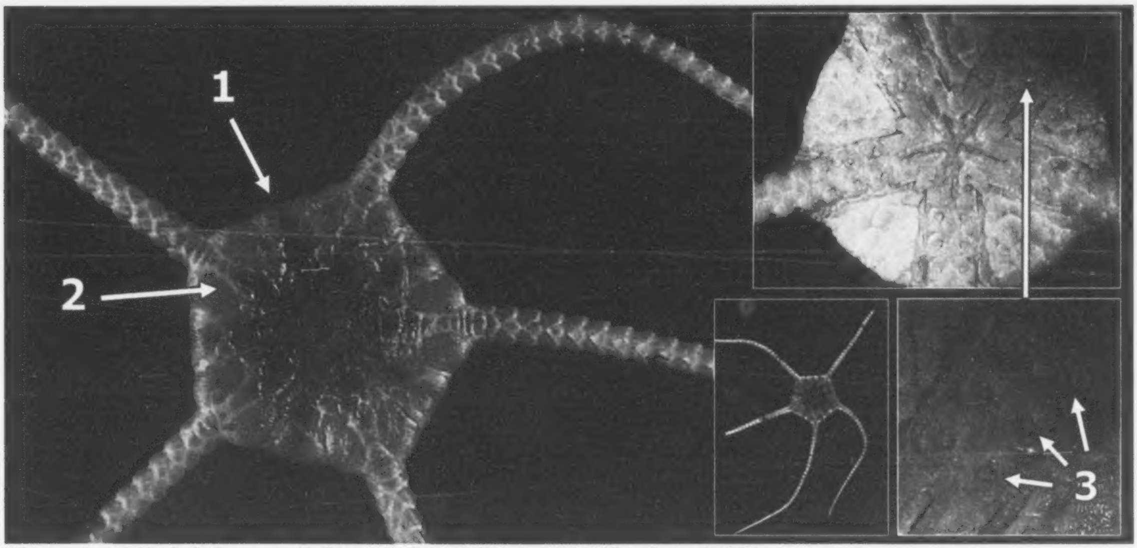


Figure 34. Tile brittle star, *Ophiosphalma jolliense* (McClendon, 1909)

Ophiura bathybia H.L. Clark, 1911

Diagnostic Characters: **Disk covered with numerous small overlapping scales (1)** , many with slender spinelets. **Radial shields crescent shaped (2)**, about three times as long as wide. Upper arm plates four-sided, outer margin convex. **Oral shield large (3)**, somewhat pentagonal; five well-spaced **oral papillae (4)**. Well-marked **arm comb (5)** with small secondary comb. Oral arm plates wider than long, first two largest and in contact, succeeding plates separated, becoming rapidly smaller. Three arm spines, most aboral is longest (< one joint) others much smaller. **Tentacle pores (6)** guarded by 3 scales on each side of pore, at least proximally.

Material Examined: Fifty specimens in one lot from 4872 m, 1800 kms off Oregon.

Type Locality: Albatross 4766, north of Atka Island, Aleutian Islands, Bering Sea (52° 38' N, 174° 49' W), 1766 fms (3230 m), .

Previous Known Distribution: 220 km off Point Conception, California, 4100 m (Booth et al. 2008); Southeast Alaska to Bering Sea, 2869 – 3608 m (H.L. Clark 1911).

New Distribution: Point Conception, California to Bering Sea, 2869 – 4872 m.

Remarks: Has been collected off California, Oregon and SE Alaska but not yet in BC. Probably in deeper water not sampled by our survey. Material from Oregon increases the known maximum depth to 4872 m.

Other References: Baranova (1957), Belyaev and Litvinova (1972), H.L. Clark (1913), D'yakonov (1952).

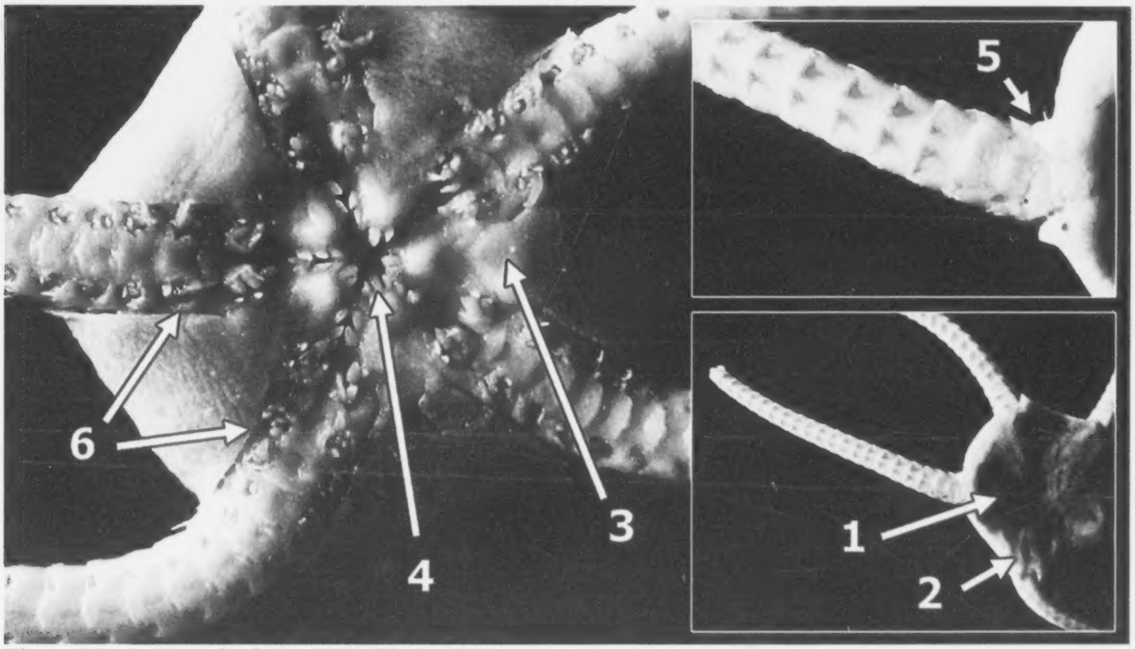
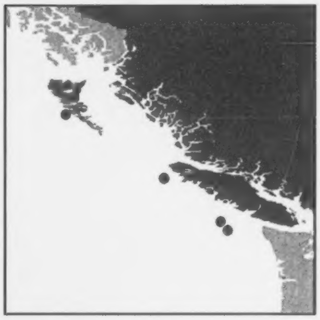


Figure 35. *Ophiura bathybia* H.L. Clark, 1911.



Ophiura cryptolepis H.L. Clark, 1911

Diagnostic Characters: **Disk (diam. 20 mm) covered with a thick granular skin (1)**, radial shields covered. Aboral arm plates four-sided, all but first two longer than wide, with a convex distal margin. **Arm comb (2)** well developed forming a conspicuous marginal fringe just distal to radial shields. Side arm plates carry seven to nine **arm spines (3)**, lowest is largest and about half a joint long.

Material Examined: Eight specimens in five lots from 819 – 1000 m between Barkley Sound and Englefield Bay, Haida Gwaii.

Type Locality: Station 3337, off Alaskan Peninsula, 512 m, green mud.

Previous Known Distribution: Washington (47°29`N) to the Bering Sea to Japan (34° 10` N), 420 – 1163 m (H.L Clark, 1911); Cape Flattery to Queen Charlotte Sound, 858 – 1280 m (Austin and Haylock 1973).

New Distribution: Washington to Haida Gwaii, BC, west to the Alaska Peninsula, Bering Sea and Japan, 420 – 1280 m.

Remarks: Material within the known distribution but farther north on the coast of BC.

Other References: Kyte (1969).

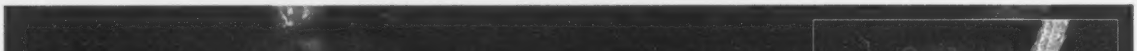
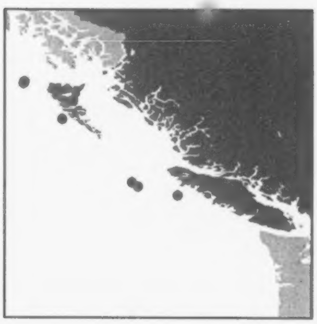


Figure 36. *Ophiura cryptolepis* H.L. Clark, 1911.



Ophiura flagellata (Lyman, 1878)

Synonyms: *Ophioglypha flagellata* Lyman

Diagnostic Characters: Live specimens have **radiating blue lines (1)** on the **smooth disk (2)** (diam. 20 mm). **Radial shields (3)** small and rounded and widely separated. Three **arm spines (4)**, longer than the joint. Arm comb of fine pointed papillae.

Material Examined: Twenty-nine specimens in eight lots from 512 – 2014 m between northern Vancouver Island and off Langara Island and Akutan Island, Aleutians.

Type Locality: Challenger Station 232, Sagami Bay, Japan, 622 m (Lyman 1878).

Previous Known Distribution: SE Bering Sea, Aleutians, Japan, Indonesia, South Africa, off Mexico, 140 – 1750 m (Imaoka et al. 1990); southeast Alaska, Bering Sea, Japan, 128 – 1602 m (H.L. Clark 1911); north of Cape San Lazaro, west coast of Baja California, 1344 m (H.L. Clark 1913).

Remarks: Within known distribution but not reported in BC before.

Other References: H.L. Clark (1913), D'yakonov (1949), Lyman (1878).

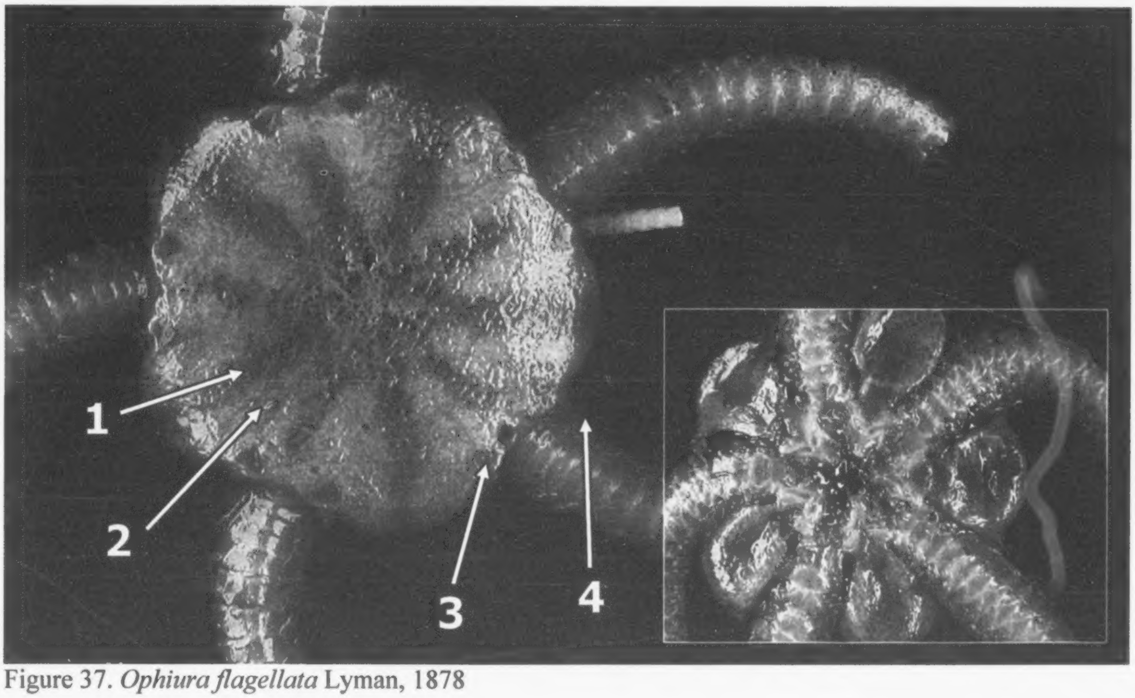
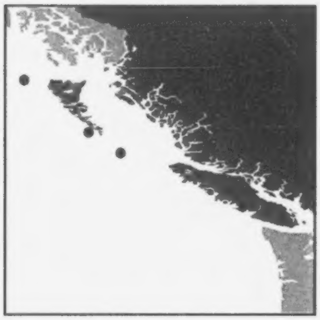


Figure 37. *Ophiura flagellata* Lyman, 1878



Stegophiura carinata D'yakonov, 1954

Diagnostic Characters: **Rounded pentahedral disk covered with numerous diverse scales (1)** ; **radial shields (2)** small, short, as long as wide, a fairly large disc scale wedged between them on the proximal side. **Arm combs (3)** of numerous fairly long slender papillae, usually with truncate tips, gradually increasing in length orally. **Oral shield (4)** large elongate oval with median constriction. Jaw with two divergent triangular papillae at the apex and 5 or 6 flat, broad papillae at each side. The first 5 or 6 oral arm shields have an **elevated median keel (5)** (knoblike) and slightly raised lateral border. Tentacle pores broad with 8 proximal and 6 distal, flat scales, gradually decreasing in number distally. Three lateral **arm spines (6)** almost as long as the joint, 6 or 7 fine secondary spines between the primaries fused into a **comb (7)**.

Material Examined: Twenty-two specimens in three lots from 1362 – 2014 m between Queen Charlotte Sound and Dixon Entrance.

Type Locality: D'yakonov (1966) did not designate a type specimen in his description but it is based on two lots from the Sea of Okhotsk at 950 and 2300 m on pebble and sand.

Previous Known Distribution: Sea of Okhotsk, 950 – 2300 m (D'yakonov 1966).

New Distribution: Sea of Okhotsk to Vancouver Island, 950 – 2300 m.

Remarks: This species has not been found in the northeast Pacific before so this should be considered a tentative identification pending confirmation by other experts in the field. Extends the range south to Vancouver Island. D'yakonov (1966) is an english translation of the original 1954 description.

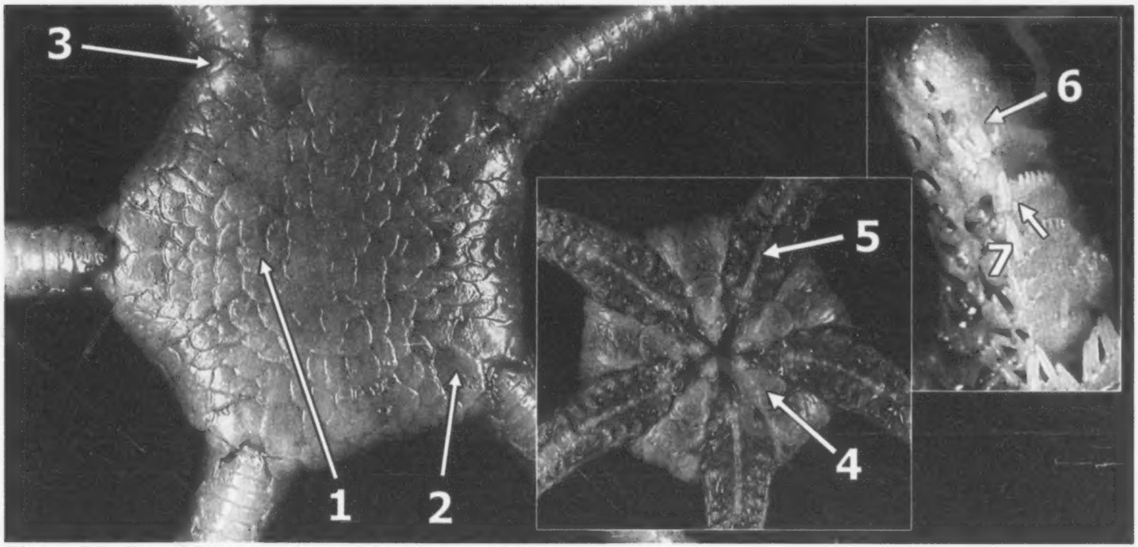
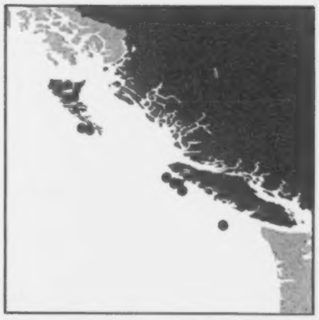


Figure 38. *Stegophiura carinata* D'yakonov, 1954



Infraorder Gnathophiurina
Superfamily Gnathophiuridae
Family Amphiuridae

Amphiura diomedeae Lütken and Mortensen, 1899

Diagnostic Characters: Disk (diam. 14 mm) **indented interradially (1), arms 7 – 8 times the diameter of disk (2)**. Disk covered with **small scales (3)**, scales on the oral side smaller and continue around to the aboral side where they are directed opposite to the aboral ones. **Radial shields (4)** as long as half the radius separated at the inner end by small scales on the outer end by a single row. Three tapering **arm spines (5)** a little longer than an arm joint, aboral shortest. Two wide rounded tentacle scales. Two **oral papillae (6)** on each side.

Material Examined: Nineteen specimens in eight lots from 922 – 2300 m west of Barkley Sound to Moresby Island.

Type Locality: Off Panama.

Previous Known Distribution: Peru, Panama and Ecuador north to Washington, also Japan, Philippines, Maldives, South Arabian coast, 71 – 3030 m (Hendler 1996); Monterey Bay California to Brooks Peninsula, BC, 549 – 1830 m (Austin and Haylock 1973).

New Distribution: Peru to Haida Gwaii, BC, 71 – 3030 m

Remarks: This study extends the known range on the North American coast from Brooks Peninsula, BC north to the south end of Haida Gwaii.

Other References: H.L. Clark (1911), H.L. Clark (1913).

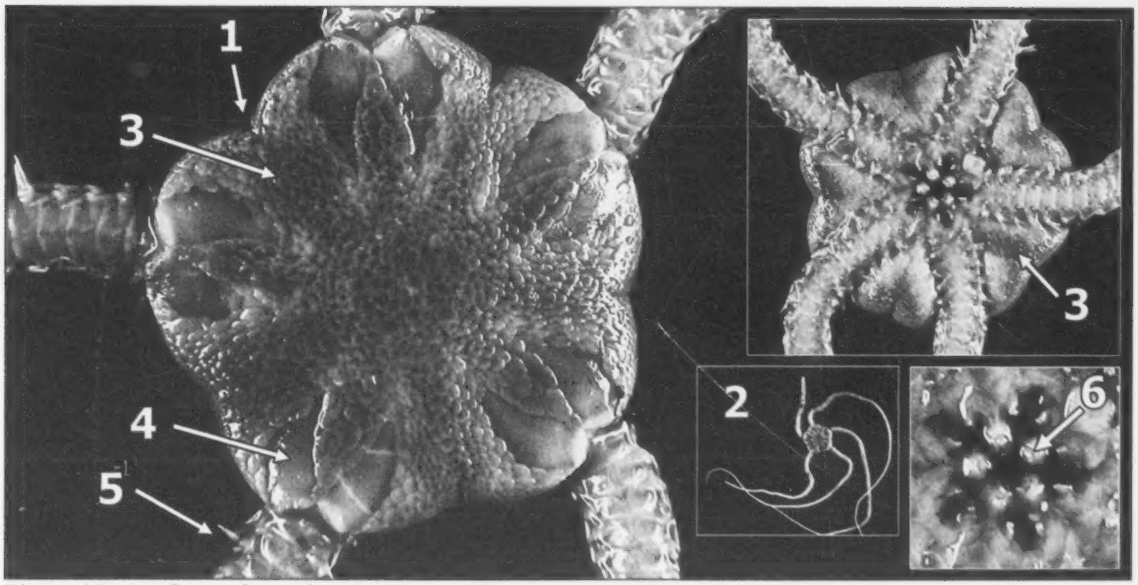
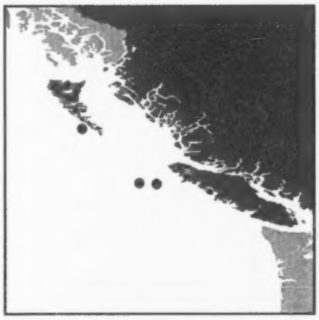


Figure 39. *Amphiura diomedeae* Lütken and Mortensen, 1899.



Subfamily Amphilepidinae

Amphilepis patens Lyman, 1879

Synonyms: *Amphilepis platytata* H.L. Clark, 1911

Diagnostic Characters: Disk (diam. 11 mm), arms 4 times longer. **Radial shields (1)** twice as long as broad, just barely in contact distally. Upper arm plates broadly pentagonal, convex distal margin, only in contact at base of arm. **Oral shields (2)** triangular, **adoral plates (3)** large, wider distally. Two **oral papillae (4)** on each side of jaw, and a pair at the apex. Three slender arm spines, longer than a joint. No tentacle scales.

Material Examined: Twenty-two specimens in three lots from 1790 – 2300 m between Cape Scott and southern Moresby Island.

Type Locality: Off Santiago, Chile, Challenger Station 299, 2160 fathoms.

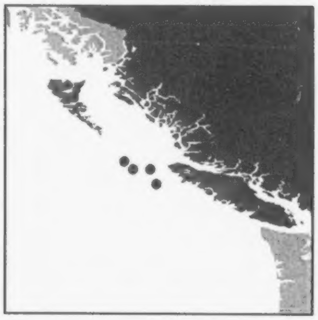
Previous Known Distribution: Chile, South America (type locality) to Cape Scott, Vancouver Island, 2200 m (Austin and Haylock 1973).

New Distribution: Chile to Moresby Island, BC, 1790 – 2300 m.

Remarks: This study extends the northern range from Cape Scott to Moresby Island.

Other References: Booth et al. (2008).

Figure 40. *Amphilepis patens* Lyman, 1879. Drawings after H.L. Clark, (1911).



Infraorder Ophiolepidina
Family Ophiolepididae

Ophiomusium glabrum **Lütken and Mortensen, 1899**

Synonyms: Possibly a senior synonym to *O. multispinum* H.L. Clark, 1911 (Figure 43) according to H.L. Clark (1913).

Diagnostic Characters: Disk (diam. ≤32 mm); 7 – 8 close set **oral papillae (1)** on each side; 7 – 11 short delicate arm spines. Small triangular upper arm plates and more or less pentagonal oral arm plates.

Material Examined: Seven specimens in four lots from 1874 – 2200 m between Quatsino Sound and Queen Charlotte Sound.

Type Locality: Not stated in Lütken and Mortensen (1899). A series of syntypes was deposited at the Smithsonian, ranging from Ecuador to Mexico in 978-2232 fms (1789-4082 m).

Previous Known Distribution: Ecuador to Baja California, Mexico, 1798 – 4082 m (Lütken and Mortensen 1899); Equator to 47° N, 878 – 4082 m (H.L. Clark 1913); off BC, Juan de Fuca Strait to Cape St. James, 119 – 2200 m (Austin and Haylock 1973) - the shallowest depth likely an error (Austin pers. comm.).

New Distribution: Ecuador to Cape St. James, Haida Gwaii; 878 – 4082 m.

Remarks: Austin (pers. comm.) feels that *O. glabrum* and *O. multispinum* should be considered separate species until intermediate forms are collected.

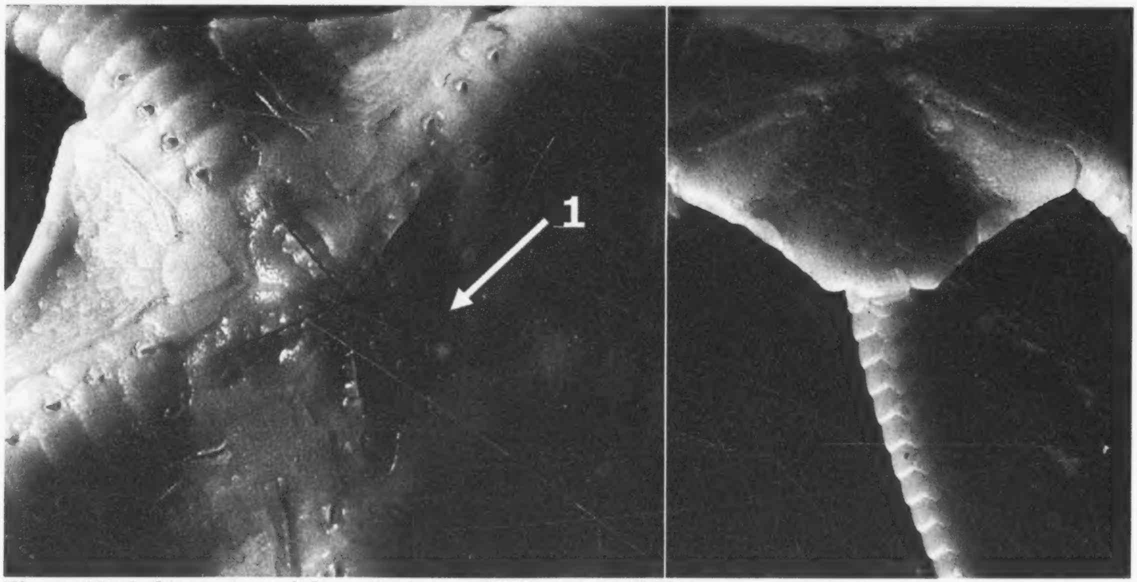
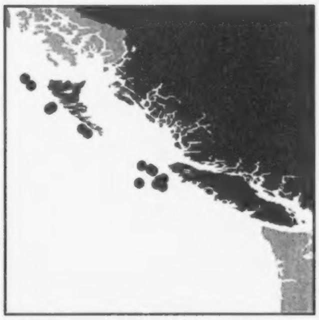


Figure 41. *Ophiomusium glabrum* Lütken and Mortensen, 1899



Ophiomusium lymani **Wyville Thompson, 1873**
Lyman's Deep-sea Brittle Star

Diagnostic Characters: Disk and arms rigid, **disk plates covered in small tubercles (1)** ; aboral plates of arms small and triangular. **Tentacle pores (2)** only on the first two arm segments. 6 – 8 rudimentary **arm spines (3)**.

Material Examined: At least 60 specimens in 15 lots from 846 – 2300 m between Brooks Peninsula on northern Vancouver Island and Dixon Entrance.

Type Locality: Off the coast of Ireland, British Isles. (Information obtained from the World Ophiuroidea Database (Stöhr and O' Hara 2007) http://www.marinespecies.org/ophiuroidea/index.php)

Previous Known Distribution: A cosmopolitan species in the Atlantic and Pacific, 130 – 3435 m (Mortensen 1927); off Oregon (Astrahantseff and Alton 1965); off Vancouver Island to the Queen Charlottes (Austin and Haylock 1973).

Remarks: When encountered in trawls, usually abundant. Most specimens have broken arms.

Other References: Ayala and Valentine (1974), H.L. Clark (1911), H.L. Clark (1913), Imaoka et al. (1990), Lyman (1883), McClendon (1909).

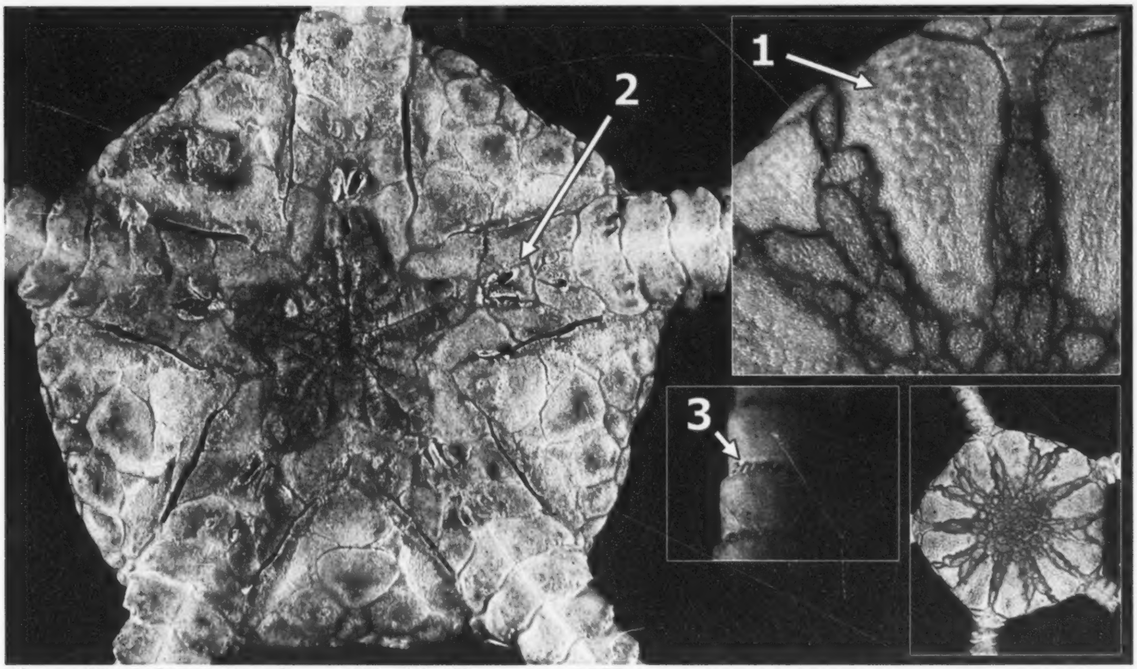
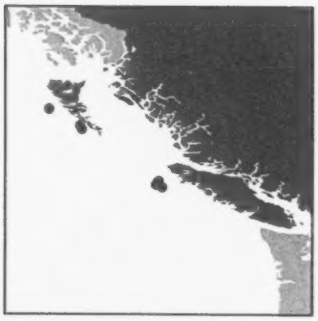


Figure 42. *Ophiomusium lymani* Wyville Thompson, 1873



Ophiomusium multispinum H.L. Clark, 1911

Synonyms: Possibly a junior synonym of *O. glabrum* Lütken and Mortensen, 1899 (Figure 41) according to H.L. Clark (1913).

Diagnostic Characters: **Disk flat, thin and pentagonal (1)**; five pairs of large **radial shields (2)**; proximal ends covered with small rounded plates embedded in skin that covers the aboral surface. Oral papillae numerous, 9 or 10 on a side. Lateral arm plates with 12 – 16 slender, crowded, pointed arm spines about ¼ the length of the arm plate. **Tentacle pores (3)** on the basal four arm segments only, with one, two or three scales.

Material Examined: Forty-six specimens in six lots from 1889 – 2300 m between Quatsino Sound and Skidegate Channel, Haida Gwaii.

Type Locality: Albatross 3074, off Washington State (47° 22' N, 125° 48' 30" W), 877 fms (1604 m), green mud

Previous Known Distribution: California, Oregon and Washington, 878 – 3219 m (Astrahantseff and Alton 1965).

New Distribution: California to Skidegate Channel, Haida Gwaii.

Remarks: H.L. Clark (1911) states that this species may be found to be identical with *O. glabrum* and that the differences could be related to size. The largest *O. glabrum* was 32 mm across the disk and the smallest *O. multispinum* was 33 mm. Austin (pers. comm.) maintains that until intermediate forms are found they should be kept as separate species.

Other References: Kyte (1969).

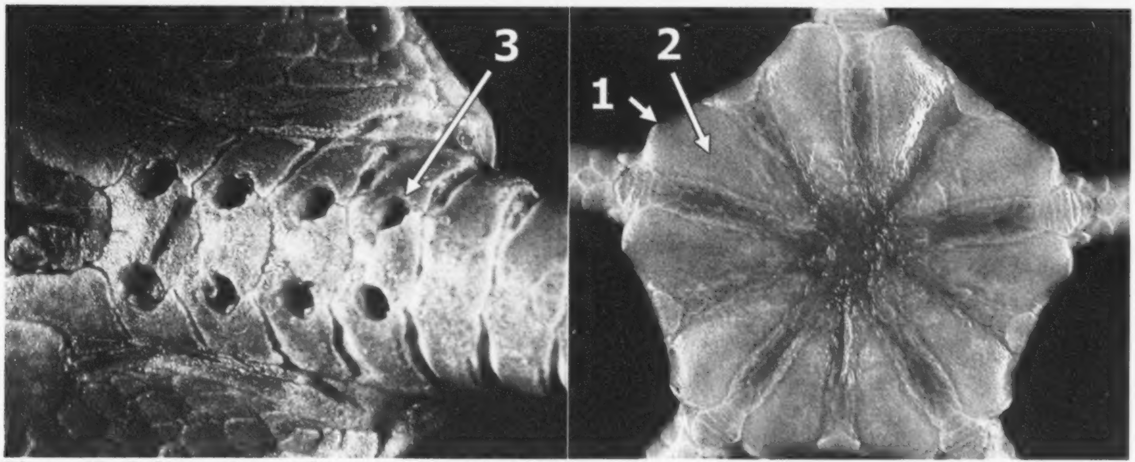


Figure 43. *Ophiomusium multispinum* H.L. Clark, 1911.

CLASS HOLOTHUROIDEA: Sea Cucumbers

Key to the genera of the deep-sea sea cucumbers (Holothuroidea) of British Columbia, Canada not known above 500 m (Figure 44). Consult Lambert (1997) for anatomy of holothuroids.See page 139 for a glossary of terms.

1a Soft bodied sea cucumbers, with or without tube feet 2
1b Small U-shaped sea cucumber covered with calcareous plates and bearing tubular extensions at each end. .... *Ypsilothuria* (p. 70)

2a Obvious tube feet and/or dorsal appendages 3
2b Without obvious tube feet (tiny wispy tube feet may be present) 7

3a Small tube feet and dorsal papillae scattered over the body or in rows 4
3b Few large tube feet with a few prominent dorsal papillae or lobe-like structures 5

4a Slender tube feet thickly scattered over the body, largest on the ventrolateral surfaces. Calcareous deposits are tables .... *Mesothuria* (p.62)
4b Double rows of tube feet on the ventrolateral surface with small ones on mid-ventral. Numerous dorsal papillae. Calcareous deposits are wheel shaped .... *Pannychia* (p. 65)

5a Anterior dorsal velum (lobe-like structure) made up of pairs of papillae fused together. No other dorsal structures 6
5b 5 – 7 pairs of robust pointed tube feet. Two pairs of large pointed papillae on dorsal surface with a small insignificant pair behind the posterior set .... *Scotoplanes* (p. 67)

6a Fleshy velum made up of two pairs of fused papillae. Eight to 10 pairs of tube feet on the ventrolateral surface. Ossicles with 3, 4 or 5 branches from central rod .... *Amperima* (p. 66)
6b Velum composed of two large and two small pairs of tube feet that merge into a lateral brim. Elongate flattened body flattened posteriorly. Ossicles are rods that branch into two at each end with vertical processes at joints .... *Peniagone* (p. 69)

7a Body smooth or wrinkled with no tube feet present; a long, tapering “tail”. Digitate tentacles 8
7b Body relatively smooth but with fine hairlike tube feet on body. Peltate tentacles 9

8a Smooth or wrinkled body tapers gradually to a long tail. Skin deposits are large perforated plates with scalloped edges and often, a central spire .... *Hedingia* (p. 72)
8b Body tapers more abruptly to a short nipple-like tail. Deposits are tables and spindle-shaped supporting rods with three large holes, also small racquet shaped plates .... *Molpadia* (p. 71)

9a Body firm and gelatinous in a rounded rectangular shape, with a ventral mouth and a dorsal anus. A few three-armed ossicles with a central spire .... *Paelopatides* (p. 63)
9b Elongate oval body with either a loose sack-like skin or more leathery. Sometimes encrusted with sand, sponge spicules, or foraminifera 10

10a Body round in cross-section but flat ventrally. Skin firm and leathery. Podia in rows on ventral side. Anus in a vertical posterior furrow, mouth is subventral .... *Pseudostichopus* (p. 64)
10b Elongate oval body with thin loose-fitting parchment-like skin. Minute hairlike tube feet scattered over body. One type of ossicle, table with three pillared spire .... *Capheira* (p. 60)

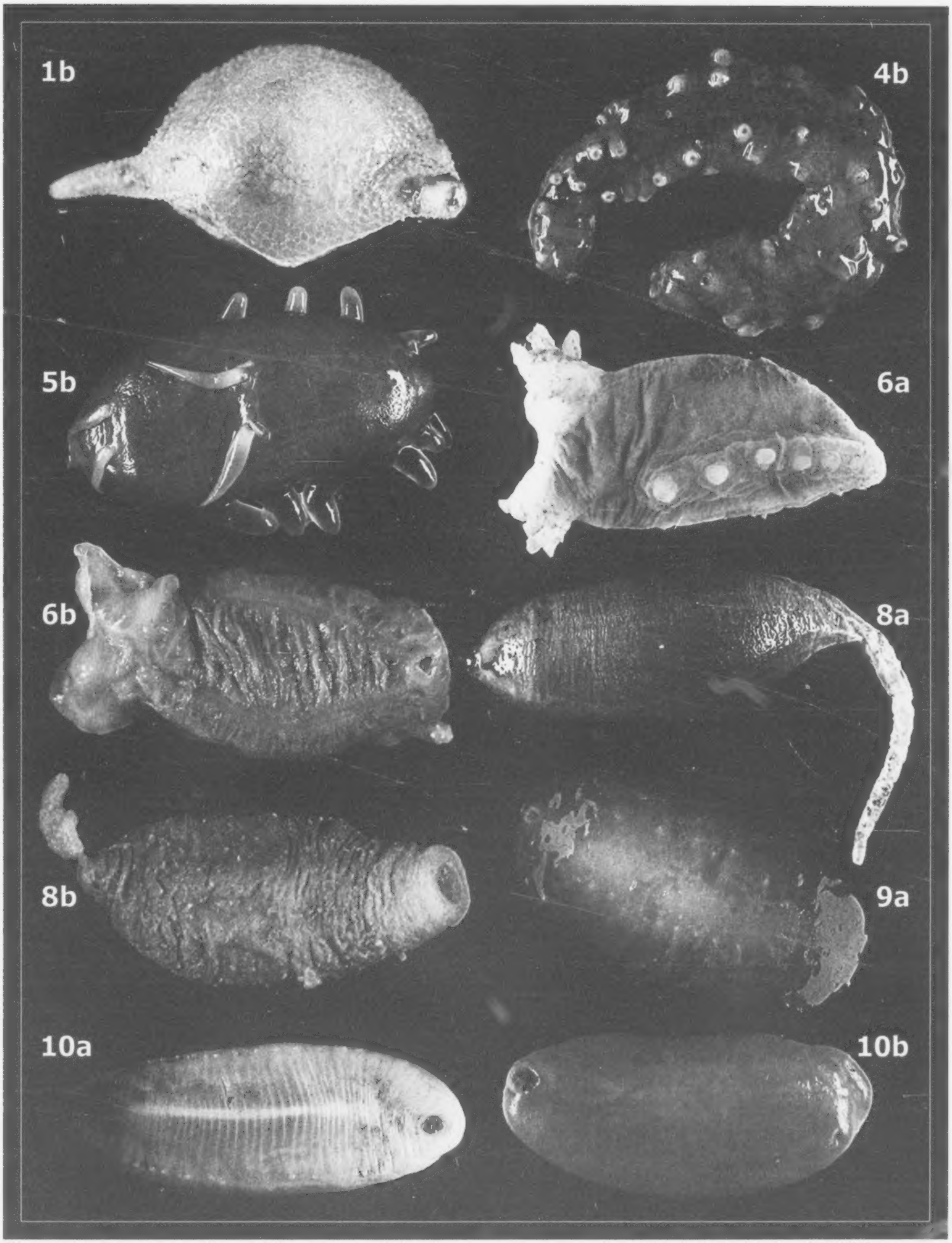
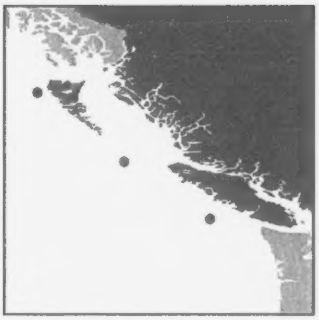

1b
4b
5b
6a
6b
8a
8b
9a
10a
10b

Figure 44. Representatives of the genera of the deep-sea sea cucumbers (Holothuroidea) of British Columbia, Canada.



Subclass Aspidochirotacea
Order Aspidochirotida
Family Synallactidae

Capheira mollis Ohshima, 1915

Diagnostic Characters: Loose sack-like elongate oval body with a thin parchment-like skin. 15 short tentacles with 5 rounded digits. Very minute hairlike tube feet not easily visible to the naked eye scattered over the body. Ossicles of one form, tables with three pillared spire arising from the centre of the disk, crossbeams at middle and at top, with a three knobbed apex; not long spines as in *C. sulcata* (Figure 46).

Material Examined: Six specimens in three lots from 1353 – 2200 m between central Vancouver Island and Rennel Sound, Haida Gwaii. A number of other *Capheira* specimens in RBCM were originally identified as *C. mollis* but a re-examination showed three spines on the spire typical of *C. sulcata*; however, the spines in our samples are not thorny as in the type description of *C. sulcata* (Figure 46). This is possibly a geographic variation. These spines are often broken off so it is difficult to differentiate between these two species. See remarks below.

Type Locality: Albatross 4767, Bowers Bank, north of Adak Island, Aleutian Islands (54° 12' N, 179° 7' 30" E), 771 fms (1410 m), green mud

Previous Known Distribution: Aleutian Islands, Bering Sea (Oshima 1915).

New Distribution: Aleutian Islands to central Vancouver Island, 1353 – 220 m.

Remarks: In a previous paper, Lambert (1984b) reported this species in BC waters but subsequently re-identified most of them as *C. sulcata*. There is some doubt whether *C. mollis* and *C. sulcata* are different species. The only differences are the spines on the top of the spire and the number of tentacles. Ludwig (1894), in his original description, could not count the tentacles properly and, based on some grooves around the mouth, assumed 30 tentacles. He commented that this was the first Elpidiid that had more than 20. For *C. mollis*, Ohshima illustrated a table with no spines on the tip of the spire and counted 15 tentacles. The experience of the senior author is that the tips are nearly always broken off and only a few are complete with three spines on the top of the spire. The type specimen is lost so this cannot be checked.

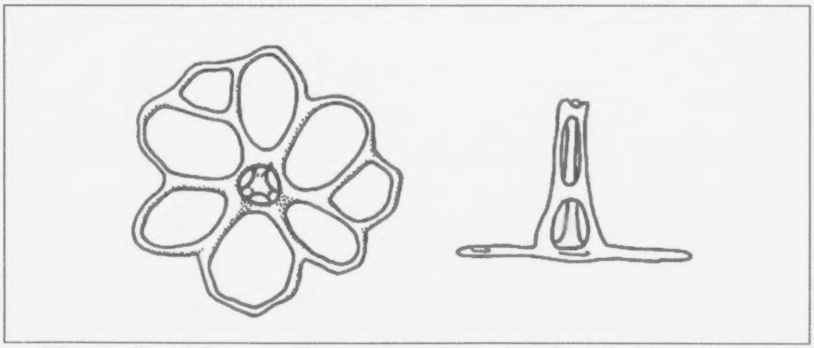
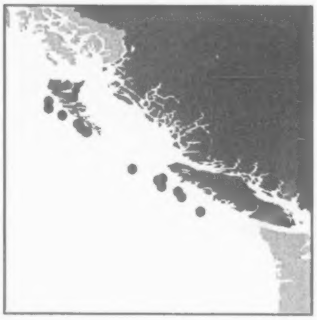


Figure 45. *Capheira mollis* ossicles. Drawing after Ohshima (1915).



Capheira sulcata Ludwig, 1893

Diagnostic Characters: Externally similar to *C. mollis* (Figure 45) with a loose-skinned body and fine wispy podia barely visible to the naked eye. The main difference from *C. mollis* is the shape of the **ossicles (1,2)**: tables with three-pillared spire topped with three long spines, rather than simple knobs as in *C. mollis*. The **specimens from British Columbia (1)** examined in this study differ from the **type description (2)** in that the top spines are smooth rather than bearing small thorns as in the original description.

Material Examined: Thirty-eight specimens in 15 lots from 706 – 2400 m between central Vancouver Island and Rennell Sound, Haida Gwaii.

Type Locality: Albatross 3398, off Ecuador (1° 7' N 80° 21' W), 1573 fms (2877 m), green mud.

Previous Known Distribution: Ecuador to Oregon, 1600 – 3400 off Oregon (Carney and Carey 1976).

New Distribution: Ecuador to Haida Gwaii, BC, 706 – 3400 m.

Remarks: This study extends the known distribution north into BC from Oregon and the minimum depth to 706 m. See *C. mollis* (Figure 45) for comments on identification of this species.

Other References: H.L. Clark 1920, Ohshima 1915

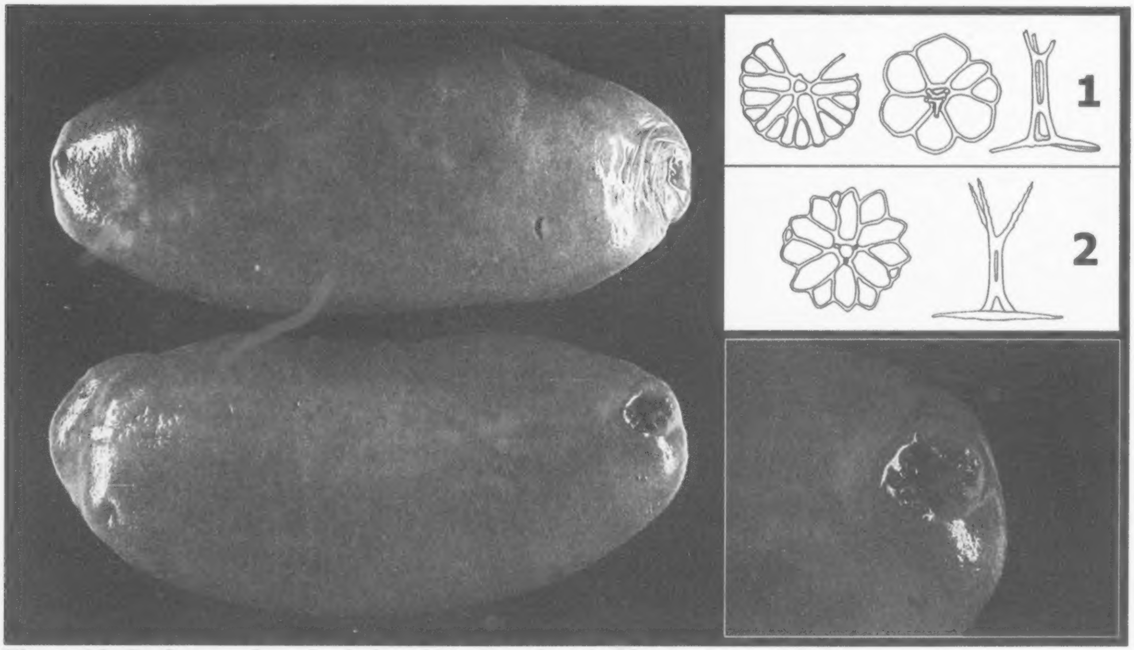
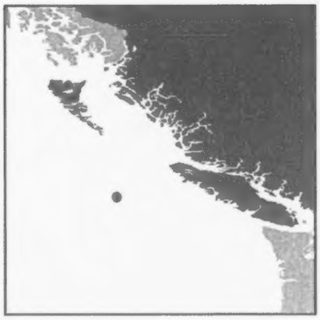


Figure 46. *Capheira sulcata* Ludwig, 1894. Drawing (2) after Ludwing (1894).



Mesothuria murrayi (Théel, 1886)

Synonyms: *Holothuria murrayi* Théel

Diagnostic Characters: Between 19 and 20 tentacles; slender podia thickly scattered over the body; podia largest on ventrolateral surfaces. Body wall thin and roughened by tips of ossicle spires. Ossicles are tables with a central hole and 6 – 8 holes around the periphery. Spire with one cross beam and three rods that flare at the summit, each rod ends in 2 – 3 short prongs.

Material Examined: One specimen from 1864 m Station P1504 Explorer Ridge; Tunnicliffe collection Univ. of Victoria.

Type Locality: Challenger Station 300 off Chile, 2515 m, globigerina ooze (Théel 1886).

Previous Known Distribution: West of Chile, off Strait of Gibraltar, Azores, Goto Islands West of Kyushu (Ohshima 1915); Hawaii, 483 – 563 (Fisher 1907).

New Distribution: Chile to Explorer Ridge, northwest of Vancouver Island, 483 – 2515 m.

Remarks: First specimen from the northeast Pacific.

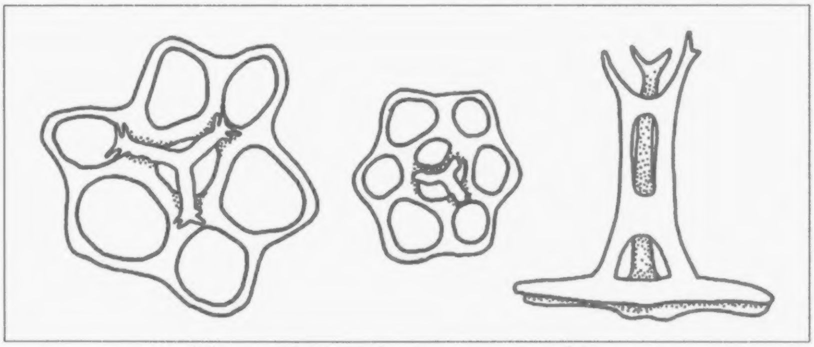
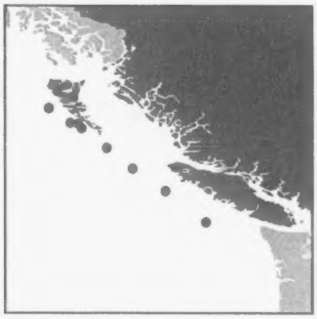


Figure 47. *Mesothuria murrayi* ossicles.



Paelopatides confundens Théel, 1886

Diagnostic Characters: Large (up to 30 cm) rounded rectangular body of a firm, gelatinous consistency, **purple in colour (1)**. **Mouth (2)** ventral surrounded by 19 or 20 tentacles, **anus (3)** dorsal and posterior. **Ossicles (4)** three-armed with tall or short spire, tips of arms branching.

Material Examined: At least 20 specimens in eight lots from 1986 – 2400 m between southern Vancouver Island and Skidegate Channel, Haida Gwaii.

Type Locality: The original description was based on specimens from three Challenger stations (298, 299, 300) off Valparaiso, Chile, 1375-2225 fms (2515- 4069 m), gray ooze and globigerina ooze.

Previous Known Distribution: Chile to Oregon, 2100 – 3900 m off Oregon (Carney and Carey 1976) and southern Vancouver Island, BC (Lambert 1984a).

New Distribution: Chile to Haida Gwaii, BC, 1986 – 4069 m.

Remarks: This species is difficult to identify because the specimens are often damaged in collection and ossicles are difficult to isolate. It is a wide ranging deep water species and thus would be expected here.

Other References: Alton (1972), Baranova (1969), Ludwig (1894).

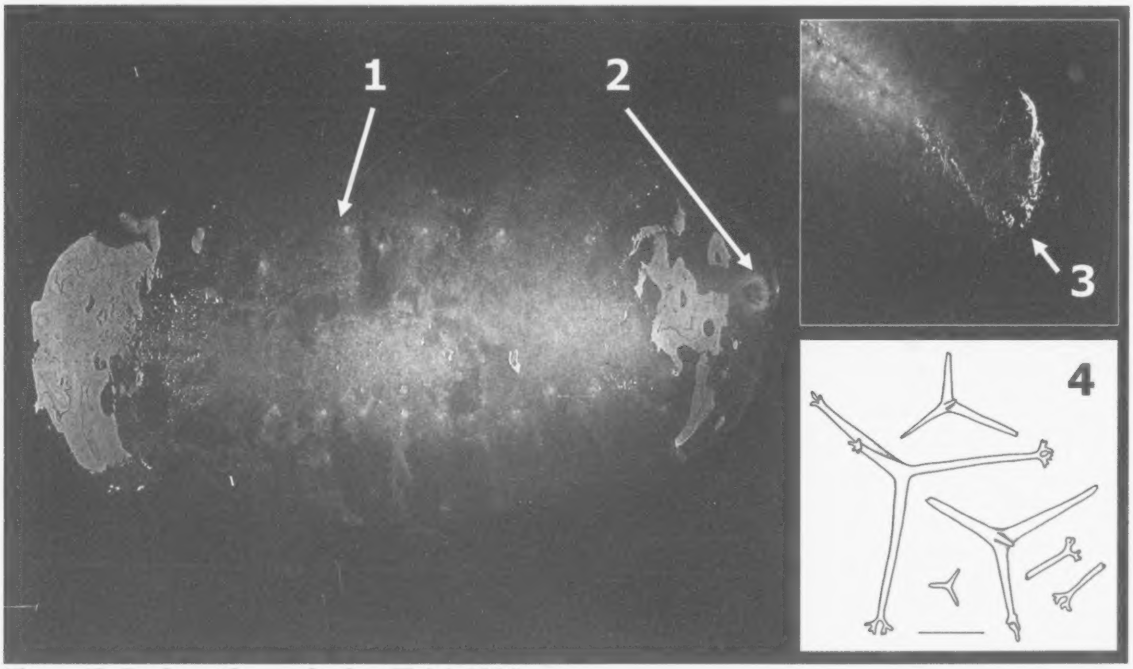
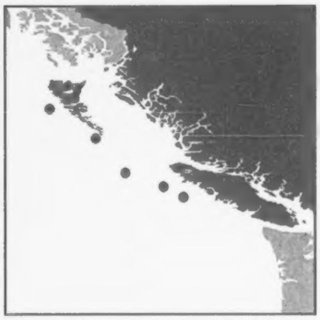


Figure 48. *Paelopatides confundens* Théel, 1886



Pseudostichopus tuberosus O'Loughlin and Ahearn, 2005

Diagnostic Characters: Compare with *Pseudostichopus mollis* (Lambert 1997). Up to 140 mm long, body wall leathery and firm, flat ventrally. **Series of ventrolateral protuberances about 2 mm wide (1).** Ventral surface with a series of **transverse ridges (2)**. Minute tube feet all over body. Irregular double rows of tapering papillae on both paired radii. Ossicles in tentacles, curved rods, blunt or finely spinous or smooth. Gonad ossicles small unbranched rods, typically with a central swelling.

Material Examined: Twenty-two specimens in five lots from 1859 – 2105 m central Vancouver Island and off Skidegate Channel, Haida Gwaii.

Type Locality: Off Oregon (45° 43'N), 1920 m.

Previous Known Distribution: Southern California to Oregon, 1920 – 1937 m (O'Loughlin and Ahearn 2005).

New Distribution: Southern California to Haida Gwaii, BC, 1859 – 2105 m.

Remarks: Specimens noted here were found in lots previously identified as *Pseudostichopus mollis*. See Lambert (1997) for description of *P. mollis* from shallower water.

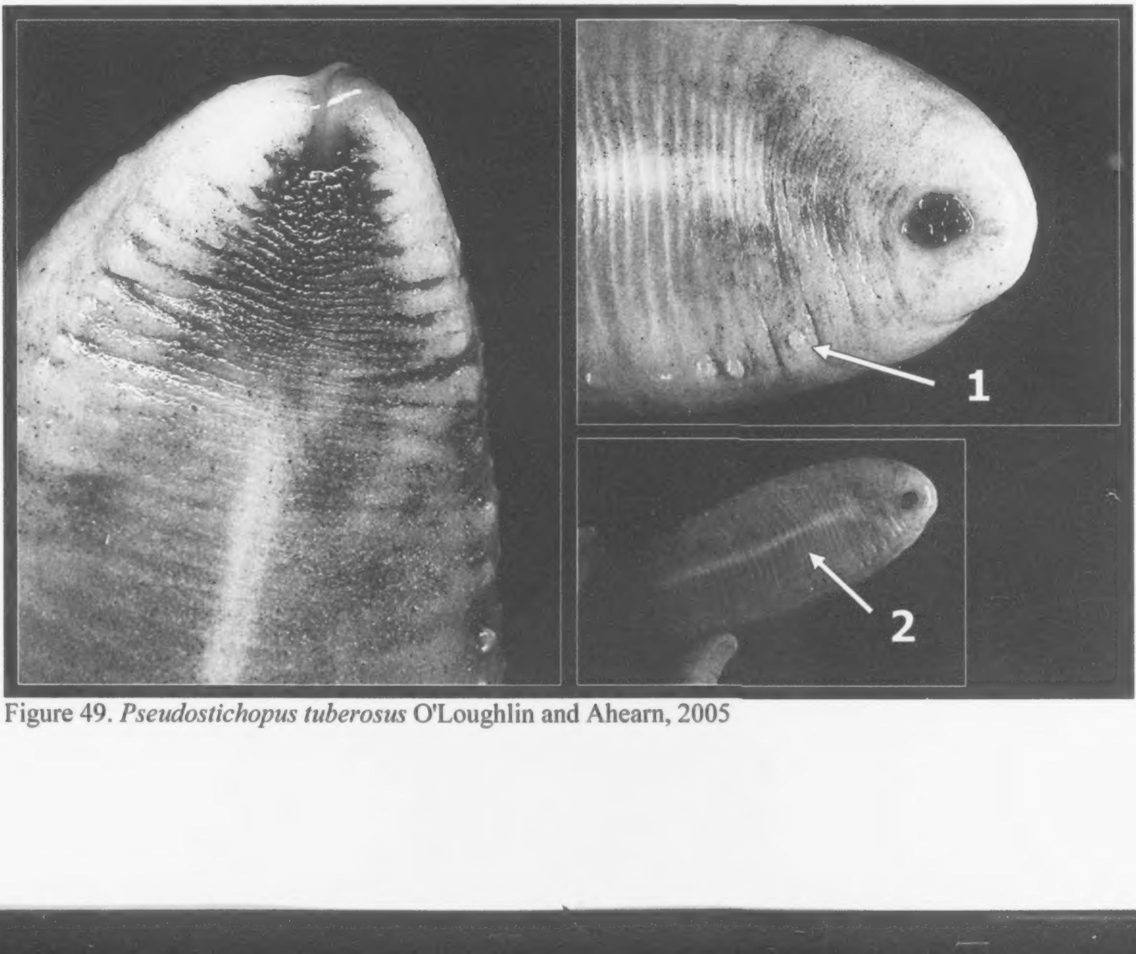
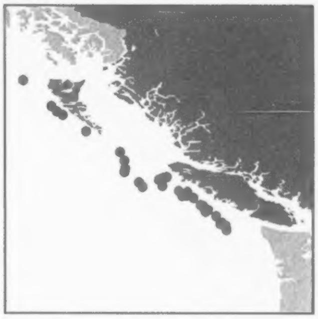


Figure 49. *Pseudostichopus tuberosus* O'Loughlin and Ahearn, 2005



Order Elasipoda (Deep-sea Cucumbers)
Family Laetmogonidae

Pannychia moseleyi Théel, 1881

Synonyms: *Pannychia multiradiata* Sluiter, 1901; *Pannychia pallida* Fisher, 1907

Diagnostic Characters: Twenty tentacles. **Ventrolateral tube feet (1)** in double rows, **mid-ventral tube feet (2)** smaller. Dorsal papillae numerous and small and scattered over the dorsum. Scattered small papillae may be in the ventral interradius. In the skin **ossicles shaped like wheels (3)** of two sizes, small type about 50 μ in diameter with 10 – 12 spokes and a larger type 70 – 320 μ in diameter and 11 – 19 spokes. Rod-shaped ossicles in the dorsum, ventrum, tube feet and papillae.

Material Examined: At least 150 specimens in 33 lots from 513 – 2200 m between Juan de Fuca Strait and Dixon Entrance.

Type Locality: Off New South Wales, Australia, 1737 m, gray ooze (Théel 1886).

Previous Known Distribution: A wide-ranging species from the southern Pacific near New Zealand and Australia to Peru, Gulf of Panama, Hawaii, northern Japan, Aleutian Islands, and off northwestern North America, 212 – 2598 m (Hansen 1975).

Remarks: This species is highly variable and has resulted in the description of many forms and varieties (Hansen 1975). He found most of the variations could occur in one geographic location. The colour of the species in one geographic region can vary from violet to whitish and some may have red sucking disks on the tube feet. It is a very common deep water species in BC and shows many of the variations described by Hansen.

Other References: Cherbonnier and Féral (1981), Pawson and Ahearn (2001).

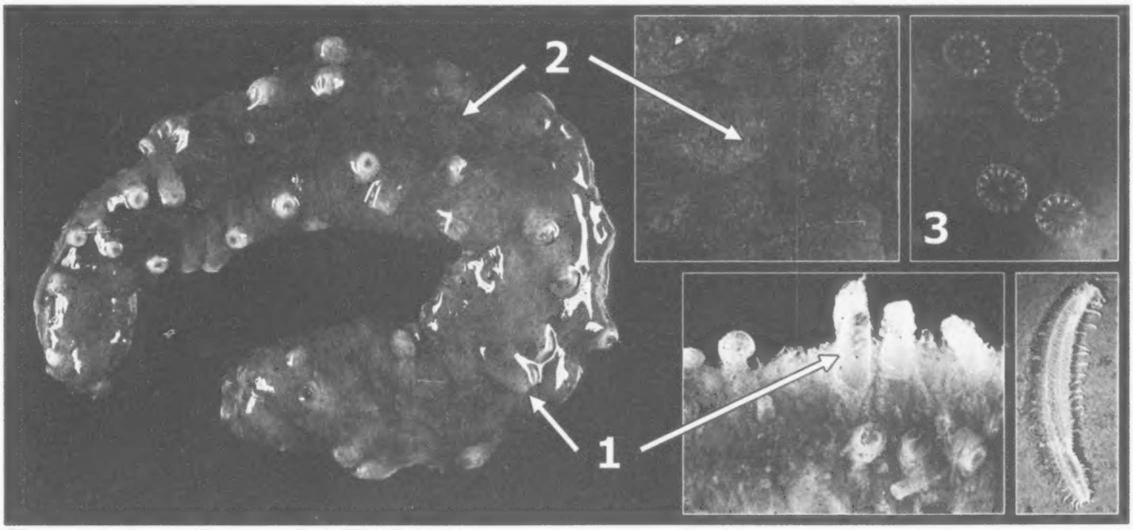
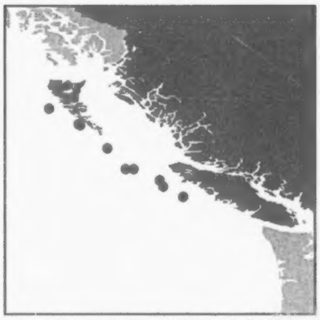


Figure 50. *Pannychia moseleyi* Théel, 1881



Family Elpidiidae

Amperima naresi (Théel, 1882)

Synonyms: *Peniagone naresi* Théel; *Periamma naresi* Hansen, 1956; *Periamma tetramerum* H.L. Clark, 1920.

Diagnostic Characters: Ovoid body with 8 – 10 pairs of **tube feet bordering the ventral sole (1)** and decreasing in size posteriorly. A **large fleshy velum (2)** on the anterior dorsal composed of two pairs of papillae. Slender **ossicles (3)** with 3, 4 or 5 rod-shaped branches radiating from a central rod, many with irregular knobs (apophyses). Also occasional c-shaped and s-shaped rods.

Material Examined: Fifty-one specimens in 10 lots from 1889 – 2400 m between northern Vancouver Island and Skidegate Channel, Haida Gwaii.

Type Locality: Challenger Station 158, between Australia and the Antarctic, 3292 m.

Previous Known Distribution: Antarctic and Indo-Pacific, 2010 – 7130 m (Hansen 1975); As *Amperima* aff. *naresi* off Oregon (Alton 1972); BC off Triangle Island (Lambert 1984b).

New Distribution: Antarctic, Indo-Pacific, Oregon to Haida Gwaii, BC; 1889 – 7130 m.

Remarks: Previously a single lot collected at the northern tip of Vancouver Island, now well represented by 10 more lots.

Other References: Agatep (1967).

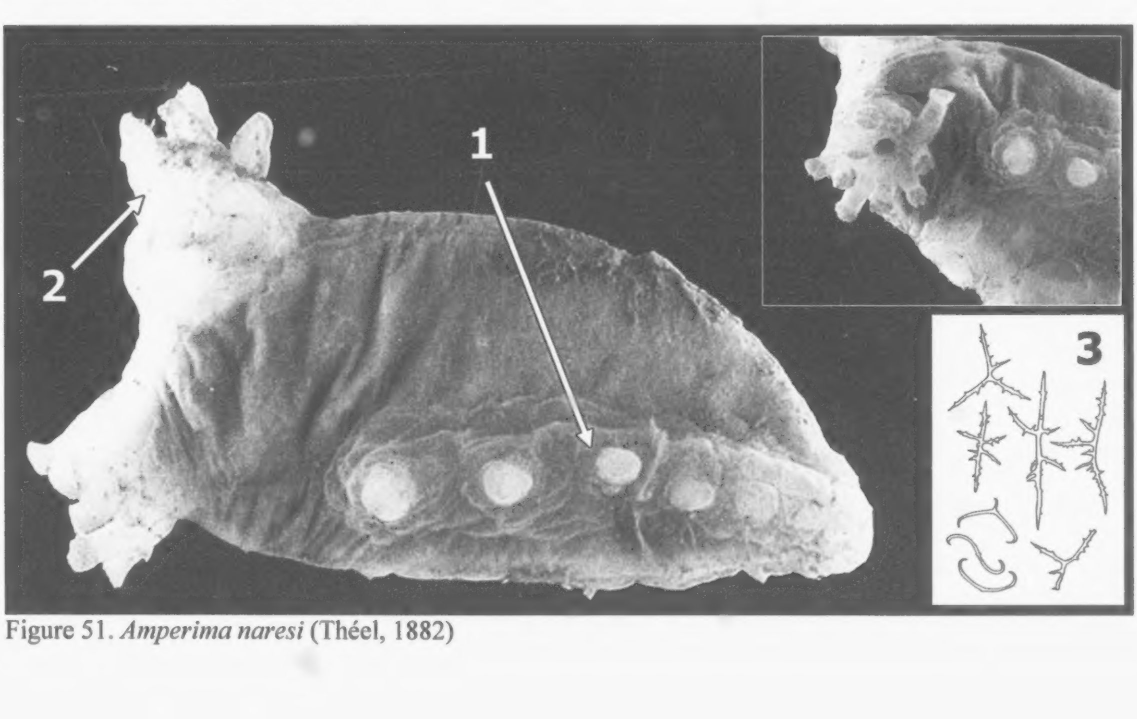
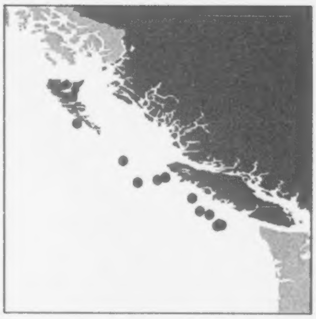


Figure 51. *Amperima naresi* (Théel, 1882)



Scotoplanes theeli Ohshima, 1915

Diagnostic Characters: Oval body (width 30-35 % of body length) with 10 **anterior tentacles (1)**; 6 – 7 pairs of robust, pointed **tube feet (2)**; **two pairs of large dorsal papillae (3)** and a pair of insignificant papillae behind the posterior pair. The large middle pair is in the centre of the body. **Two types of ossicles (4)**, small C-shaped ones and large curved rods (400-500 µm) with small and sparse spines situated mainly at the ends. Skin thick and smooth.

Material Examined: Approximately 100 specimens in 13 lots from 725 – 2200 m between southern Vancouver Island and Gowgaia Bay, Haida Gwaii.

Type Locality: Albatross 5032 or 5033, Nemuro Strait, east end of Hokkaido, Japan (approx 44° 5' N, 145° 30 E), 300-533 fms (549-975m), type specimen lost but collected from one of these stations.

Known Distribution: Pacific Ocean species, known on the coasts of Japan, in the region of Kurile Islands and on the continental shelf of North America. Depth from 545 - 2500 m (Gebruk 1983)

Remarks: Another species, *Scotoplanes clarki* Hansen, 1975 occurs in deep water off Panama and perhaps the northern shelf of South America but it has not been collected off North America. It is similar but has a warty body. Hansen (1975) synonymized *Scotoplanes theeli* with *Scotoplanes globosa*; however, Gebruk (1983) re-established *S. theeli* and described *S. kurilensis* as well.

Other References: Carney and Carey (1976), D'yakonov et al. (1958), Ohshima (1915).

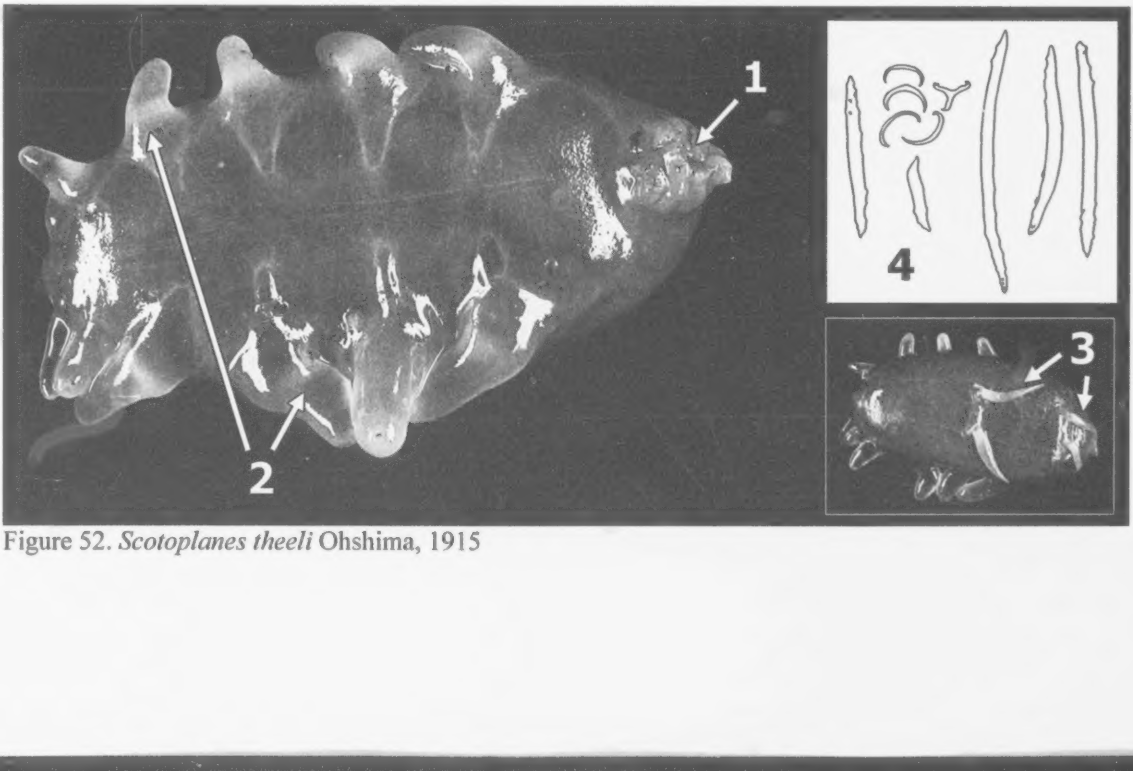
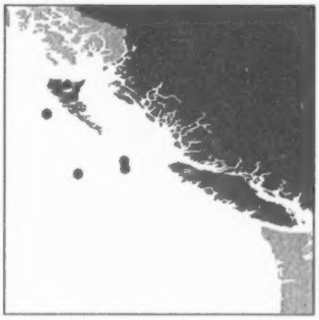


Figure 52. *Scotoplanes theeli* Ohshima, 1915



Scotoplanes globosa (Théel, 1879)

Synonyms: Elpidia globosa Théel, 1879.

Diagnostic characters: Body width 40-50% of its length. Three pairs of dorsal papillae, the **middle pair (1)** situated at about 33-35% of body length from the **posterior end (2)**; the **posterior pair (3)** reduced and just behind the middle pair. Numerous long curved ossicles (1000-1200 µm) with spines along the entire length. Five or six, rarely 7, pairs of tube feet. Skin fine and smooth.

Material examined: Eight specimens in 4 lots from 2125-2926 m between Cape Scott,Vancouver Island and off Tasu Sound, Haida Gwaii.

Type locality: Challenger 157, between Australia and Antarctica (53° 55' S 108° 35' E), 1950 fms (3566 m), diatom ooze.

Known distribution: Pacific Ocean: Peru-Chile trench, Northeastern Pacific basin, region of Kermadec Trench. Atlantic Ocean: Scotia Sea and coasts of Africa (Cape Basin and in the area of the Equator). Indian Ocean: Australo-Antarctic Basin. Depth range 2100 - 5630 m (Gebruk 1983).

Remarks: Gebruk (1983) re-examined *Scotoplanes* spp. and determined that Hansen (1975) was incorrect in synonymizing several species of *Scotoplanes* within *S. globosa*. *S. globosa* is confined to the deep ocean (>2100 m) thus may occur off BC.

Other references: Carney and Carey (1976), D'yakonov (1958), Hansen (1956), Kaufmann and Smith (1997), Smith and Hamilton (1983), Thandar (1999).

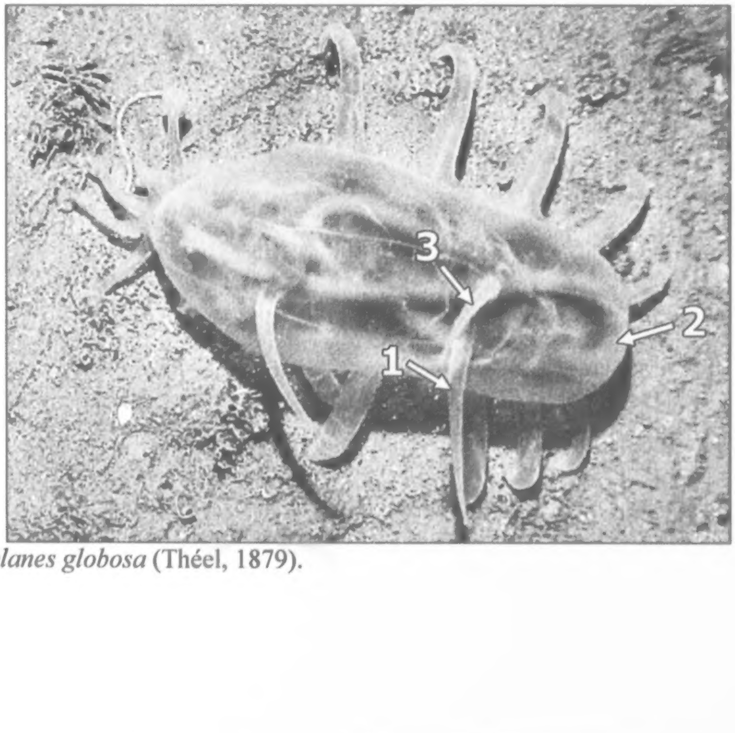
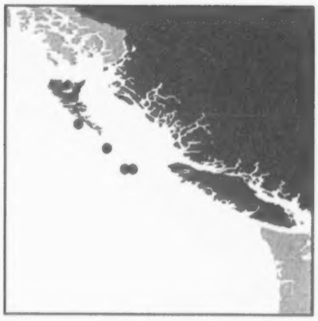


Figure 53. *Scotoplanes globosa* (Théel, 1879).



Peniagone japonica Ohshima, 1915

Diagnostic Characters: Body elongate, flattened posteriorly. About 8 pairs of **tube feet (1)** bordering the posterior half of the ventral sole decreasing in size to the posterior. **Velum (2)** well developed, composed of two pairs of large and two pairs of small papillae that gradually pass into a **lateral brim (3)** above the tube feet along the body. Ossicles are short rods branching at each end into two long processes, often thorny, some with vertical processes at the joints.

Material Examined: Fifty specimens in four lots from 2000 – 2400 m between Queen Charlotte Sound and Moresby Island tentatively identified as *Peniagone japonica.*

Type Locality: Off Kii, Honshu Japan, 1655 m (Ohshima 1915).

Previous Known Distribution: Off Japan, 1135 – 1669 m (Hansen 1975).

New Distribution: This study possibly extends the range to the west coast of North America and the maximum depth to 2400 m.

Remarks: These specimens require further study to confirm the identification.

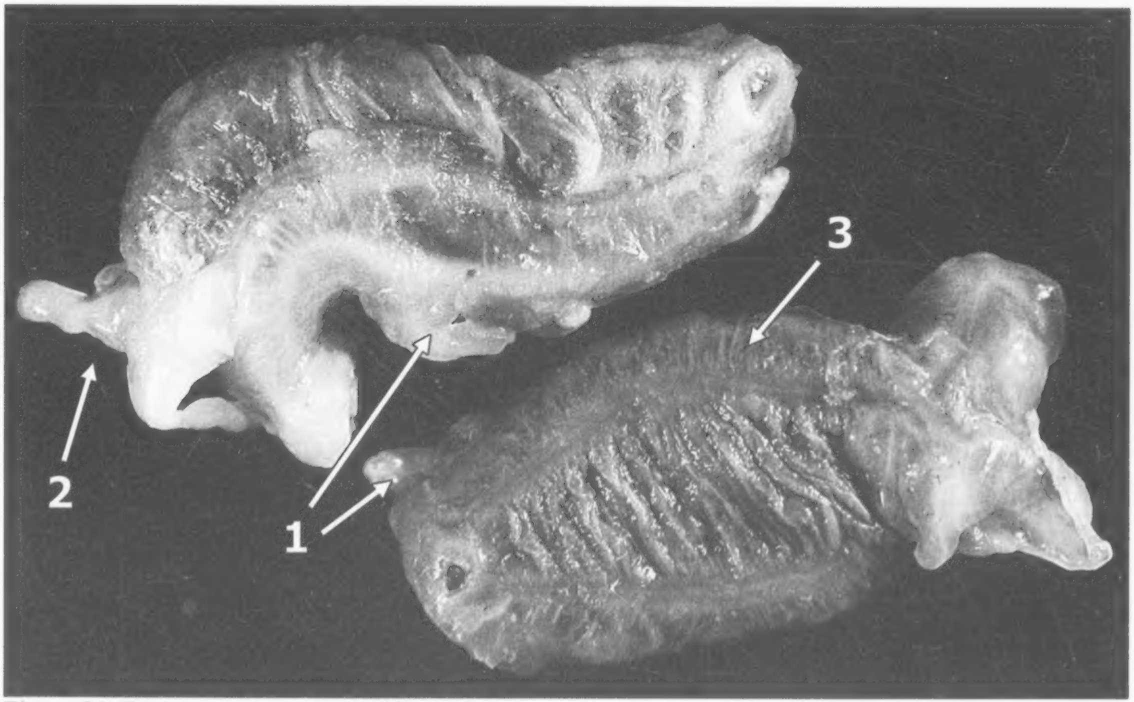
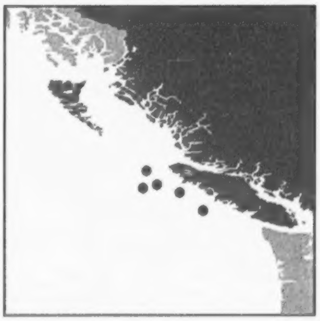


Figure 54. *Peniagone japonica* Ohshima, 1915.



Subclass Dendrochirotacea
Order Dactylochirotida
Family Ypsilothuriidae

Ypsilothuria bitentaculata **Ludwig, 1893**

Synonyms: *Sphaerothuria bitentaculata* Ludwig, *Echinocucumis typica* H.L. Clark, 1923

Diagnostic Characters: Globular to spherical sea cucumber with **plates of body wall (1)** forming a rigid test like a young sea urchin. About 25 mm along greatest curvature. Calcareous plates with uneven edges and composed of several layers, spires of plates off centre but not near the margin. Seven to eight tentacles, lateral two the largest.

Material Examined: Twenty-two specimens in five lots from 1318 – 2091 m between central Vancouver Island and off Cape Scott.

Type Locality: Albatross 3357, off Panama (6° 35` N 81° 44` W), 782 fms (1430 m), green sand.

Previous Known Distribution: Off Oregon, 2100 – 3000 m (Carney and Carey 1976); off Kyuquot in 1830 m (Lambert 1984b); circum-Pacific (Pawson 1970); Bering Sea, 4000 m (Savel'eva 1955).

Remarks: Specimens collected in this study are within the broad range of this circum-Pacific species but within BC the specimens collected off Cape Scott are slightly farther north on the coast than the previous known record in BC.

Other References: Alton (1972), Cherbonnier and Féral (1981), Heding (1942), Thandar (1999), Tyler et al. (1985).

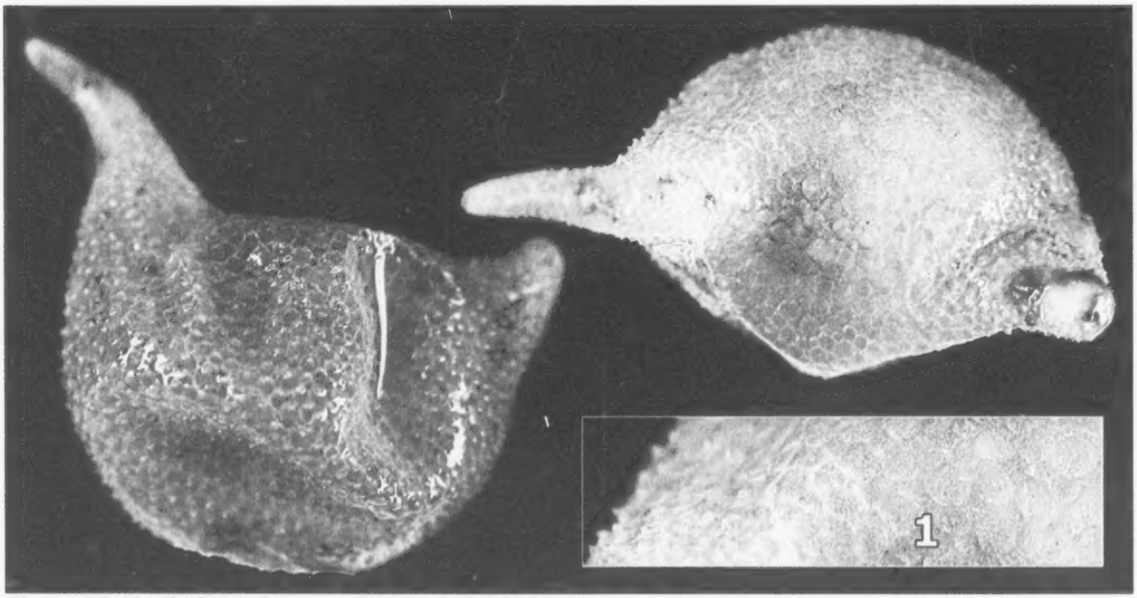
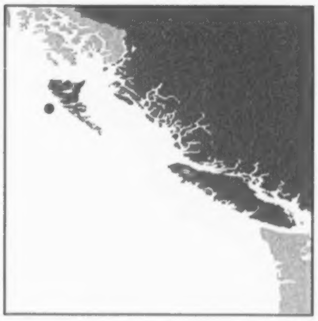


Figure 55. *Ypsilothuria bitentaculata* Ludwig, 1893



Subclass Apodacea
Order Molpadiida
Family Molpadiidae

Molpadia musculus Risso 1826

Synonyms: *Haplodactyla musculus* Grube, 1840, *Ankyroderma musculus* Petit, 1883.

Diagnostic Characters: Smooth body without podia and **a small posterior tail (1)**. Tables in the body wall predominantly with three large holes, spindle-shaped supporting rods with three holes and small racquet shaped ossicles.

Material Examined: Three specimens in one lot from 1986 – 2105 west of Skidegate Channel tentatively identified as *Molpadia musculus*.

Type Locality: North Atlantic.

Previous Known Distribution: Cosmopolitan, reported from North Atlantic, Kerguelen Islands, southern Chile, Gulf of Panama, southern California and Monterey Bay (H.L. Clark 1907); northern Oregon, 800 – 3000 m (Carney and Carey 1976); Kuril and Sakalin Island (D'yakonov et al. 1958).

Remarks: These specimens require further study to confirm the identification. Another possibility is *Molpadia borealis* Sars, 1859 but it has not been reported in the Pacific before.

Other References: Alton (1972), Cherbonnier and Féral (1981), Deichmann (1947), Pawson (1970, 1977).

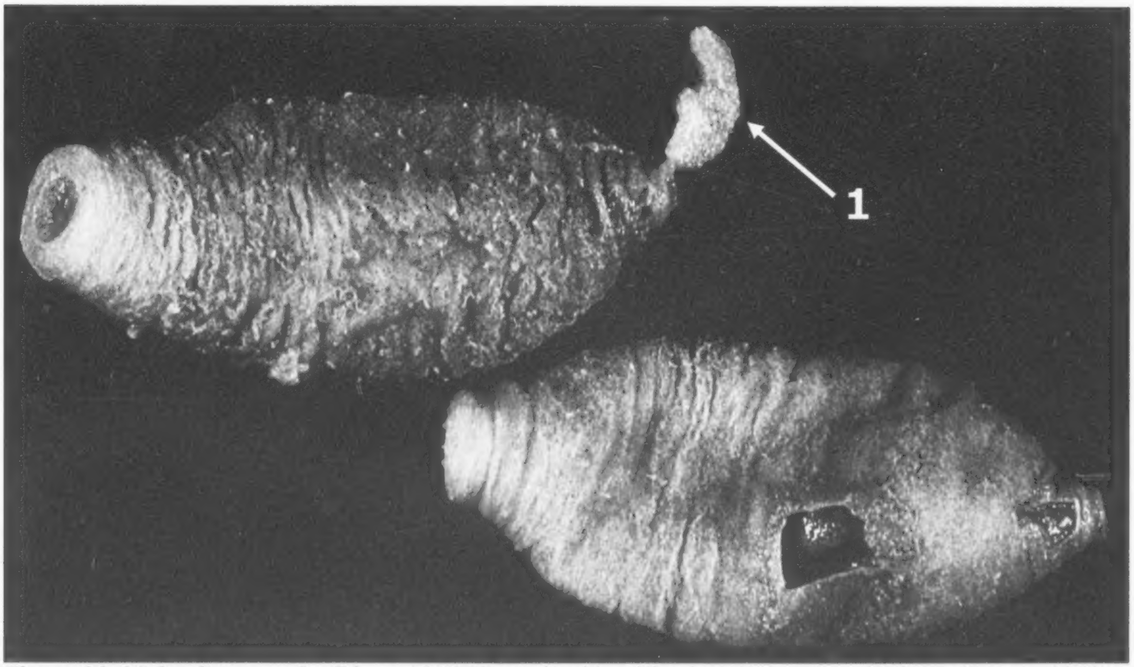
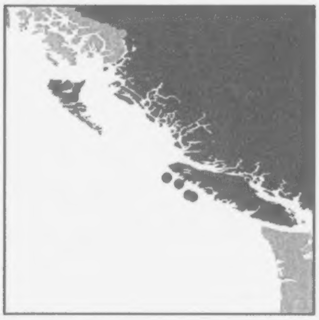


Figure 56. *Molpadia musculus* Risso, 1826 (Tentative identification: alternative: *M. borealis* Sars, 1859).



Family Caudinidae

Hedingia californica (Ludwig, 1894)
Wrinkled White Sea Cucumber

Synonyms: *Caudina californica* Ludwig, 1894;

Diagnostic Characters: Fifteen tentacles, with two pairs of digits without a terminal digit. Body **smooth (1)** or **wrinkled (2)** with a **long tail (3)**. **Skin ossicles (4)** large perforated plates with scalloped edge and spiny surface, sometimes a central spire.

Material Examined: Thirty-three specimens in six lots from 595 – 1456 m between Nootka Sound and Quatsino Sound, on Vancouver Island.

Type Locality: Albatross 3434, Gulf of California, Mexico (25° 29' 30" N, 109° 48'W), 1588 fms (2850 m), brown mud.

Previous Known Distribution: Gulf of California and southern California (Bergen 1996).

New Distribution: Baja California to Vancouver Island, 595 – 2850 m.

Remarks: Pending a more thorough investigation, this is a major range extension for this species from southern California to northern Vancouver Island.

Other References: Ludwig (1893).

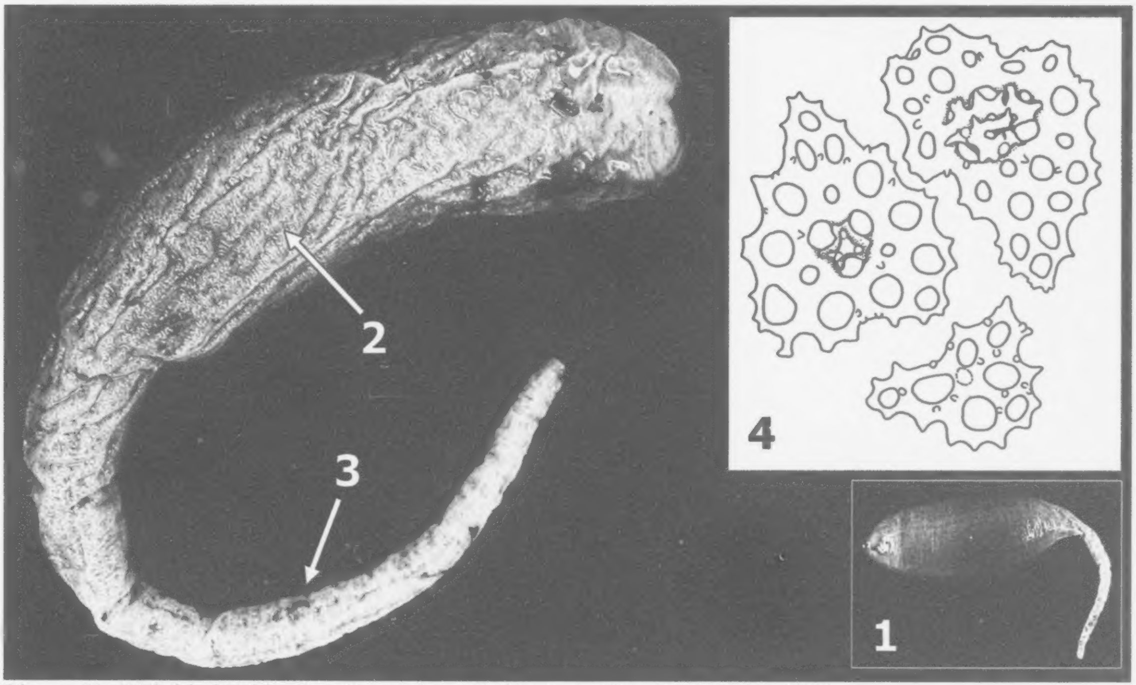


Figure 57. Wrinkled White Sea Cucumber, *Hedingia californica* Ludwig,1894

CLASS ASTEROIDEA: Sea Stars

Key to the deep-sea genera of Asteroidea found off British Columbia, Canada. Consult Lambert (2000) for illustrations of important taxonomic features. See page 139 for a glossary of terms.

1a Marginal plates well-developed and conspicuous, larger than adjoining aboral plates, forming a distinct margin along the edge of arms and disk. Aboral plates with paxillae (peg-like stumps topped with granules or spines). Papulae (gills) only on aboral side 2
1b No distinct marginal plates between aboral and oral surfaces. Papulae on aboral and oral sides. Arms cylindrical in cross-section. 16

2a Tube feet pointed or conical, without a suction disk. Aboral side covered with paxillae 3
2b Tube feet with a suction cup. Aboral side naked, or covered with paxillae, granules, or spines 8

3a Fleshy cone (appendix-like) in centre of the disk; specialized ciliated grooves between marginals (cribriform organs). 4
3b No fleshy cone but occasional slightly raised area in centre. No cribriform organs 5

4a Fleshy cone in the centre of disk. Three cribriform organs (Brown grooves between marginal plates) in each interradius. No channels in the oral inter-radii........ *Eremicaster* (p.)
4b Simple cribriform organs between all marginals........ *Ctenodiscus* (see Lambert 2000)

5a Superomarginal plates less prominent than the inferomarginals so that the latter form the outline of the body. Marginal plates covered by uniform spines, granules or scales. 6
5b Supero and inferomarginals similar in size, together forming the margin. Marginals with spines in a single vertical series. Arms long, flat, and pointed. 7

6a Superomarginals less than half as wide as inferomarginals. A deep channel between superomarginal plates as wide as the height of the ridge (visible when spine cover is removed) .... *Leptychaster* (p. 80)
6b Madreporite obscured by paxillae. No prominent granules along aboral margin of inferomarginal plates .... *Dipsacaster* (p. 79)

7a Marginal spines obvious, forming a fringe. No grooves between marginals. Oral interradial areas small but plates continue for about half the length of the arm. Aboral surface of uniform low paxillae in oblique lines........ *Thrissacanthias* (p. 82_)
7b Obvious grooves between the marginal plates. Marginal spines short. .... *Psilaster* (p. 81)

8a Marginal plates with long sharp spines. Arms long, flat and tapering. Superomarginals and inferomarginals alternating 9
8b Marginal plates without long, sharp spines. Superomarginals more or less in line with inferomarginals. Body pentagonal or star-shaped 11

9a Papulae in discrete oval patches on the aboral surface........ *Pectinaster* (p. 90)
9b Papulae distributed on the aboral surface as far as the 13th marginal. A more or less prominent odd marginal plate with a robust spine in all or some of the interradial angles. 10

10a Superomarginal plates with 2 or 3 coarse spines. Inferomarginals with 2 – 5 laterally protruding major spines. Odd marginals not conspicuous, generally missing in some interradii .... *Nearchaster* (p. 88)

10b Superomarginals with a single coarse spine, inferomarginals with 1 or 2. Odd marginal conspicuous and present in all interradii .... *Benthopecten* (p. 85)

11a A single spinelike tooth at the apex of each jaw. Pedicellariae are pectinate, if present .... *Pseudarchaster* (p. 97)
11b No odd median tooth at apex of each jaw. Bivalve pedicellariae 12

12a Aboral side with granules and sometimes pedicellariae on paxillae, no spines 13
12b Aboral side with low blunt spines and bivalved pedicellariae surrounded by granules. Marginal plates with short thick spines. Short arms 15

13a Pentagonal disk. No spines on marginal or aboral plates, just coarse granules 14
13b Arms flat and broad at the base, tapering to a narrow tip........ *Mediaster* (p. 96)

14a Two furrow spines and one large club-shaped subambulacral; no pedicellariae on adambulacrals .... *Cladaster* (p. 93)
14b Adambulacrals with 2 – 6 furrow spines and short spinelets on aboral .... *Ceramaster* (p. 91)

15a Very few spines on aboral, circular or elliptical aboral plates with flattened granules and large bivalved pedicellariae. Each supero- and inferomarginal bears one spine.....Cryptopeltaster (p. 94)
15b Aboral surface with short thick spines. Spines and pedicellariae surrounded by small granules. Bivalved pedicellariae tall and narrow .... *Hippasteria* (p. 95)

16a Aboral side with supradorsal membrane that connects to the exterior by a centrally located pore or osculum. Adambulacral plates with a transverse comb of spinelets 17
16b No supradorsal membrane........ 19

17a Transverse comb of adambulacral spines joined by a membrane. The distal spine of this comb is elongated and supports an actinolateral membrane that may or may not define the edge of the arm 18
17b More delicate and flatter than Pteraster. Adambulacral spine comb not joined by a weblike membrane .... *Hymenaster* (p. 102)

18a Adambulacral combs of one kind........ *Pteraster* (p. 105)
18b Adambulacral combs of two kinds; a prominent comb alternating with a smaller comb set back from the furrow .... *Diplopteraster* (see Lambert 2000)

19a Five arms........ 20
19b More than five arms 29

20a Aboral side with plates or paxillae bearing a single or clusters of sharp spines 21
20b Small disk with long cylindrical arms. Skeleton consists of low ridges with short spinelets in tight groups or single file........ *Henricia* (p. 111)

21a Aboral side with a meshlike skeleton bearing paxillae with tufts of fine, glassy spinelets. Papulae in the spaces between the meshes 22
21b Aboral skeleton composed of uniform plates in regular longitudinal rows. Straight pedicellariae present 23

22a A meshlike aboral skeleton forming longitudinal rows and bearing tall slender paxillae with slender spinelets each ending with two or three sharp points. Two pronounced marginal series of paxillae .... *Lophaster* (p. 99)

22b Similar aboral skeleton but marginal series not paxilliform or larger than the aboral spines. Spines of paxillae enclosed in a fleshy sheath united with neighbouring spines.......... *Peribolaster* (p. 110)

23a Disk small. Arms long, narrow, subcylindrical with plates forming longitudinal rows. Adambulacral plates of two kinds, large ones projecting into the ambulacral groove, alternating with smaller, simple ones. Only straight pedicellariae.......... 24

23b Small forms with relatively small disk. Skeleton forming a meshlike pattern with rectangular papular areas. Straight and crossed pedicellariae present, the latter scattered over the body. No adoral carina (first few pairs of adjacent adambulacrals touching).......... 26

24a Rows of cross-shaped plates forming a net-like skeleton (=reticulate) with open papular areas; primary spines on all plates; aboral and oral intermediate plates all similar in form 25

24b Rows of overlapping shingle-like plates (imbricate) forming a relatively solid skeleton with only small papular areas; primary spines absent from most plates except carinals and marginals; oral intermediate plates differentiated from adradial and carinal series; internal buttress absent.......... *Zoroaster* (p. 115)

25a Internal buttress absent.......... *Sagenaster* (p. 114)

25b Internal buttress present .... *Myxoderma* (p. 113)

26a Distal to the adambulacrals is a prominent longitudinal series of inferomarginal spines, larger than the superomarginals. First pair of adambulacral plates after the oral plates, are narrowly separated or just touching across the furrow. Tube feet in four rows, at least proximally.......... 27

26b Inferomarginal spines not conspicuously larger than the superomarginals and do not form a prominent longitudinal row on the distal side of the adambulacrals. The latter are the most prominent, in transverse rows of two to five. First pair of adambulacrals are widely separated interradially. Two rows of tube feet.......... 28

27a Adambulacral plates with two spines (diplacanthid) or a mixture of one and two. Straight pedicellariae not unguiculate (like clasped hands) or broadly spatulate. Superomarginal plates regularly four-lobed.......... *Tarsaster* (p. 119)

27b Adambulacral plates normally with one spine (monacanthid). Straight pedicellariae unguiculate or strongly spatulate. Superomarginal plates three-lobed or irregularly four-lobed. .... *Ampheraster* (p. 116)

28a Crossed pedicellariae of two types, larger type with slender jaws and four large claw-like terminal teeth, and smaller ones with numerous small terminal teeth. Actinal intermediate plates in a netlike transverse series increasing in number in the middle third of the arm. Pedicellaster (p. 118)

28b Crossed pedicellariae, small with numerous terminal teeth of same size, occasional large unguiculate straight pedicellariae.......... *Anteliaster* (p. 117)

29a Small, delicate, circular disk, arms slender, sharply differentiated from the disk, often broken off (deciduous). Crossed pedicellariae abundant, straight absent. 31

29b Broad disk, seven to twelve arms. Prominent rows of marginal paxillae. Adambulacral spines consist of two sets at right angles to each other 30

30a Prominent inferomarginals possess several spines on the tip. Superomarginals smaller but differentiated from the aboral paxillae .... *Solaster* (p. 100)

30b A row of marginal paxillae made up of single prominent transverse paxillae alternating with two smaller horizontal plates with small low spines .... *Heterozonias* (p. 98)

31a Eight to fifteen arms with transverse, raised ridges (costae)..32
31b Nine to twenty arms without raised, transverse ridges..35

32a Pedicellariae on the costae and between 33
32b No pedicellariae or plates on the skin between the costae 34

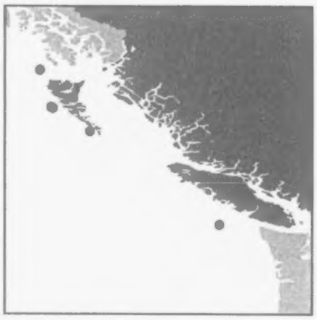
33a Intercostal band of pedicellariae, no perforated plates.................................*Hymenodiscus* (p. 126)
33b Intercostal band of pedicellariae plus perforated plates in the skin......................*Astrolirus* (p. 125)

34a Eleven arms, fairly large disk, 25 – 27 costae bearing pedicellariae. Disk with circular plates bearing 1 – 3 spines. .... Astrocles (p. 122)
34b Twelve to fifteen arms bearing 35 – 40 costae. Disk with prominent solitary spines. Two furrow spines and two subambulacrals .... *Brisinga* (p. 121)

35a Nine or ten arms. Disk and arms soft and covered in mucus. Adambulacrals spines arranged in a semi-circular comb...*Asthenactis* (p. 109)
35b Number of arms eleven or greater...36

36a Arms constricted at the base but inflated in the first third 37
36b Arms not constricted at the base or inflated. First twelve adambulacral spines with a flaring tip..... ....*Freyellaster* (p. 124)

37a Seventeen arms (12 – 20). Disk with aboral circular plates bearing a spine with membranous sheath. Wormlike papulae in groups of 2 – 15. One long adambulacral spine. Superomarginal spines...*Rathbunaster* (p. 120)
37b Eleven to twelve arms. Disk with plates bearing 4 or 5 short spinelets. One furrow spine and one adambulacral spine with enlarged tip on each plate..*Freyella* (p. 123)



Order Paxillosida
Family Astropectinidae

Dipsacaster anoplus Fisher, 1910

Diagnostic Characters: Resembles *Leptychaster* but the arms are wider, bulging slightly at the base. **Marginal plates (1)** without enlarged spines or tubercles and **fasciolar grooves between marginals (2)** deep and wider than the ridges. **Paxillae (3)** with a crown of 30 to 40 spinelets about half on the periphery. Papulae in fives and sixes around the paxillae but absent from centre of disc. **Adambulacrals (4)** with marginal series of five or six sub-cylindrical spinelets and 12 – 18 spinelets on oral surface decreasing in size.

Material Examined: Six specimens in five lots from 340 to 1240 m depth between central Vancouver Island and Dixon Entrance.

Type Locality: Albatross 3347, off Cascade Head, Oregon (45° 9' 35" N, 124° 45' W), 345 fms (631 m), mud (Fisher 1911).

Previous Known Distribution: Washington to San Diego, California, 549 – 1463 m (Fisher 1911); Sea of Okhotsk (D'yakonov 1950) and the Bering Sea, 2200 m (Baranova 1957); Barkley Sound to Skidegate, Haida Gwaii, 461 – 1830 m (Lambert 1978b); off Yakutat Bay, Alaska 146 m and Dixon Entrance 340 m (Lambert 1999).

Distribution: On the west coast of North America from San Diego, California to Yakutat Bay, Alaska and Bering Sea and Okhotsk Sea, 146 – 2200 m.

Other References: A.M. Clark (1989).

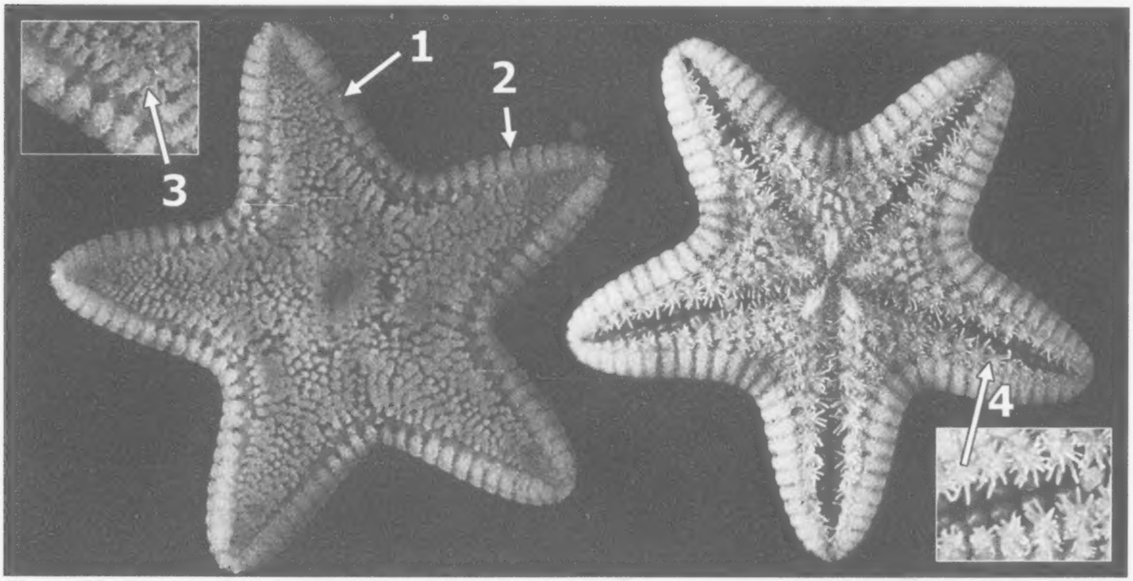
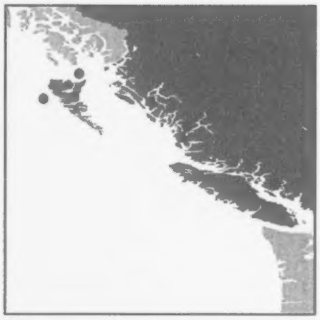


Figure 58. *Dipsacaster anoplus* Fisher, 1910



Dipsacaster borealis Fisher, 1910

Diagnostic Characters: **Aboral paxillae (1)** regularly arranged in oblique transverse rows and similar in size; each paxilla is crowned with 70 to 80 spinelets; 6 papulae around each paxilla; **large marginal plates (2)** , superomarginals bearing low compact granules with one or two inconspicuous tubercles; the inferomarginals define the contour of the ray and bear overlapping scale-like granules. Adambulacral plates with **four to six long, stout, round-tipped furrow spines (3)**, the four largest are flattened with sides to the furrow, on the oral surface of the plate 6 – 9 spinelets.

Material Examined: Thirty-seven specimens in seven lots from 240 to 1195 m between Burke Channel and the Gulf of Alaska.

Type Locality: Albatross 3331, north of Unalaska Island, Alaska (54° 1' 40" N, 166° 48' 50" W), 350 fms (640 m), mud.

Previous Known Distribution: Bering Sea and south of Aleutian Islands, 221 – 642 m (Fisher 1911); 200 – 642 m (Lambert 1999); 221 – 642 m (A.M. Clark 1989); Gulf of Alaska to Dixon Entrance, 201 – 340 m (Lambert 1978a).

New Distribution: Bering Sea to Cape St James, 201 – 1195 m.

Remarks: This study extends the known range to the vicinity of Cape St James, Haida Gwaii.

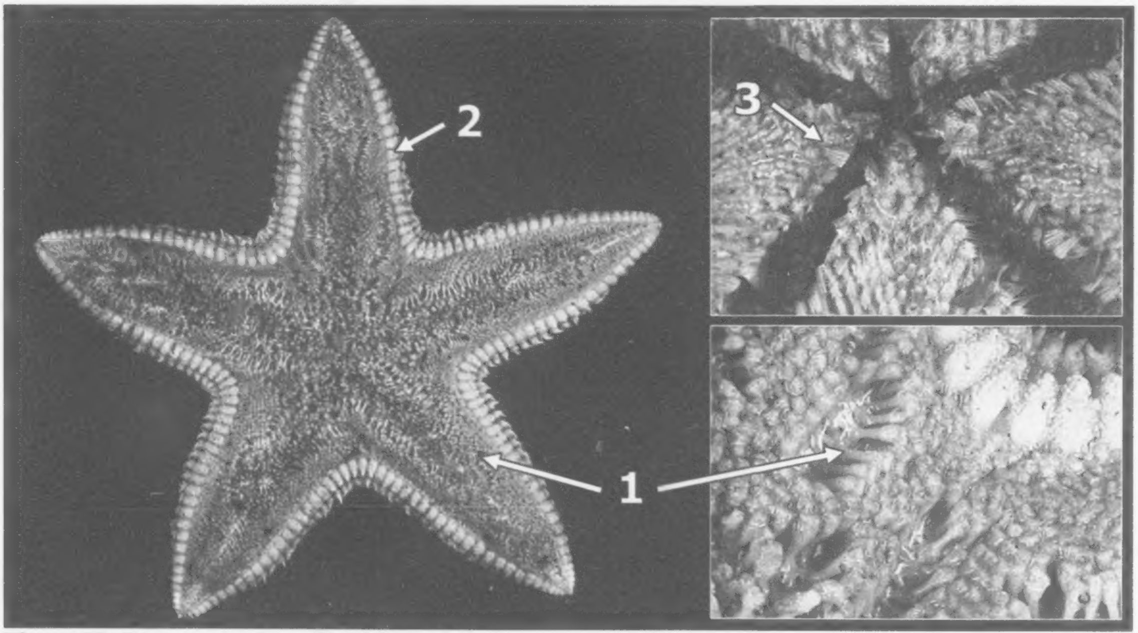
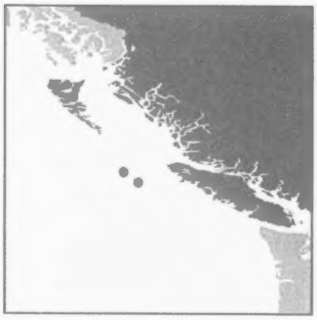


Figure 59. *Dipsacaster borealis* Fisher, 1910



Dispsacaster laetmophilus Fisher, 1910

Diagnostic Characters: Aboral plates not lobed; marginal plates massive; **superomarginals nearly square (1)** beyond proximal fourth of ray, covered with close-set delicate spinelets like those of paxillae rather than squamous granules. **Inferomarginals narrow (2)** and covered with delicate, imbricating, narrow squamiform spinelets, which become enlarged into 5 – 7 small tapering spines on aboral end of plate, and forming a serrate edge to the ray. Seven **adambulacral furrow spines (3)** strongly compressed and blade-like with edges to the furrow; tip broader than the base; on the oral surface of the plate 10 to 18 slender tapering spinelets, decreasing in size distally.

Material Examined: Three specimens in two lots from 1790 – 1903 m west of Cape Scott, Vancouver Island.

Type Locality: Albatross 3340, south of Alaska Peninsula between Unalaska Island and Kodiak Island (55° 26' N, 155° 26' W), 695 fms (1271 m), mud.

Previous Known Distribution: Alaska Peninsula, 1271 m (Fisher 1911).

New Distribution: Alaska Peninsula to Vancouver Island; 1271 – 1903 m (this study).

Remarks: Previously known only from the type locality. This study extends the known range south to Vancouver Island.

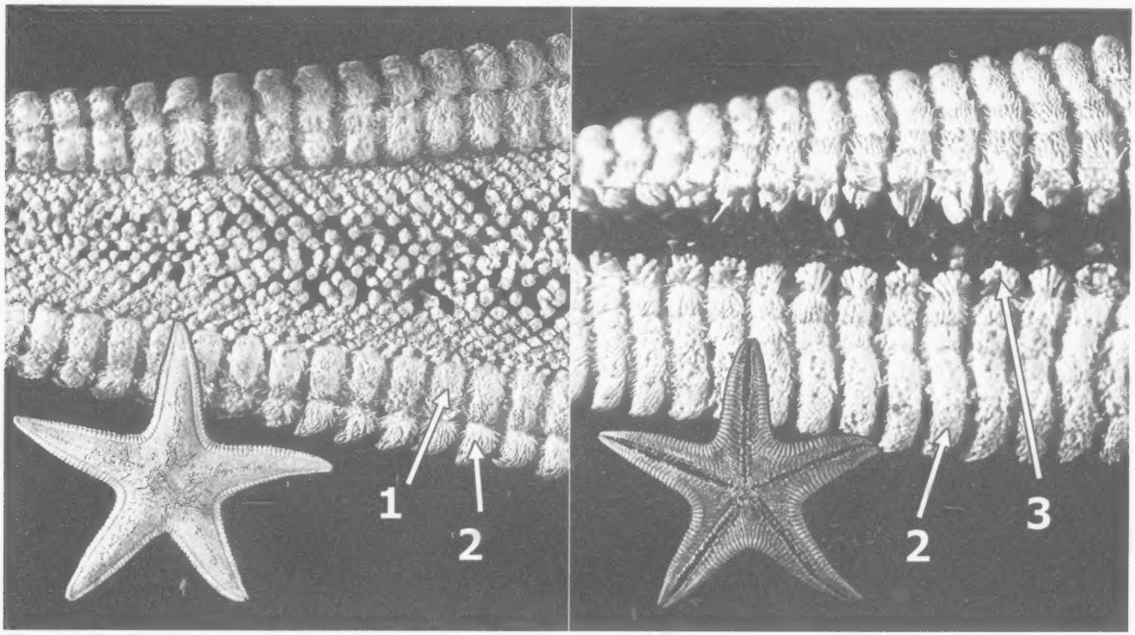


Figure 60. *Dispsacaster laetmophilus* Fisher, 1910.

Leptychaster inermis (Ludwig, 1905)

Synonyms: *Parastropecten inermis* Ludwig, 1905

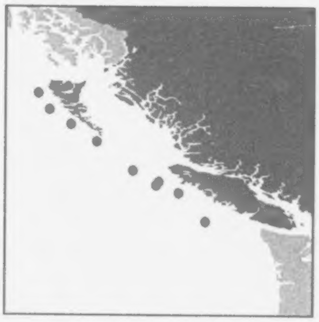
Diagnostic Characters: Small species; R= 1.83 cm, R= 1.7 – 2.4r. Differs from *Leptychaster anomalus* by the presence of 6 or 7 marginal spines on each adambulacral plate and four papulae around each paxilla but is, otherwise, similar to *L. anomalus*. 14 – 17 superomarginals.

Material Examined: None collected in this study.

Type Locality: Gulf of Panama, 1271 m (Ludwig 1905).

Previous Known Distribution: Bering Sea opposite Avacha Bay; Monterey Bay, Gulf of Panama, Galapagos Islands 1200 – 2000 m on mud or mud-sand (D'yakonov 1950); Baja California and Monterey Bay, 1180 – 1205 m (H.L. Clark 1913).

Remarks: Fisher (1911) put *Parastropecten inermis* into *Leptychaster,* and noted that *P. inermis* appeared to be based on young specimens. This may explain the minor differences in spine and papulae counts between *L. inermis* and *L. anomalus* but until this is investigated we shall keep them as separate species. Apart from the records from the Bering Sea this species has not been collected north of Monterey Bay on the west coast of North America but is potentially in British Columbia in deep water.



Psilaster pectinatus (Fisher, 1905)

Synonyms: *Bathybiaster pectinatus* Fisher, 1905; *Plutonaster abyssicola* Ludwig, 1905

Diagnostic Characters: Rays tapering continuously, lateral wall of marginal plates nearly vertical. About 46 superomarginals from inter-radial to tip; upper end of superomarginal plate with a **sharp spine (1)**, sometimes two. Usually a **low epiproctal cone (2)** in the center of the disk. **Aboral paxillae (3)** with four central stubby spinelets surrounded by ten to fifteen slender ones. Adambulacral plates with a furrow series of eight spinelets and two or three longitudinal series of three or four on the **oral surface (4)**, each with a pulpy sheath.

Material Examined: Twenty-seven specimens in nine lots from 1707 – 2300 m between Juan de Fuca Strait and Graham Island.

Type Locality: Albatross 4387, southeast of San Clemente Island, California (32° 29' 30" N, 118° 5' W), 1937 m, mud (Fisher 1911).

Known Distribution: A wide range from the Bering Sea to the Bay of Panama; 1889 – 2972 m ; 1500 – 2970 m (A.M. Clark 1989); 1500 – 3000 m (D'yakonov 1950).

Remarks: Specimens from this study fall well within the normal geographic range of this species. It is a fairly distinctive species but might be initially confused with *Thrissacanthias penicillatus* (Figure 62).

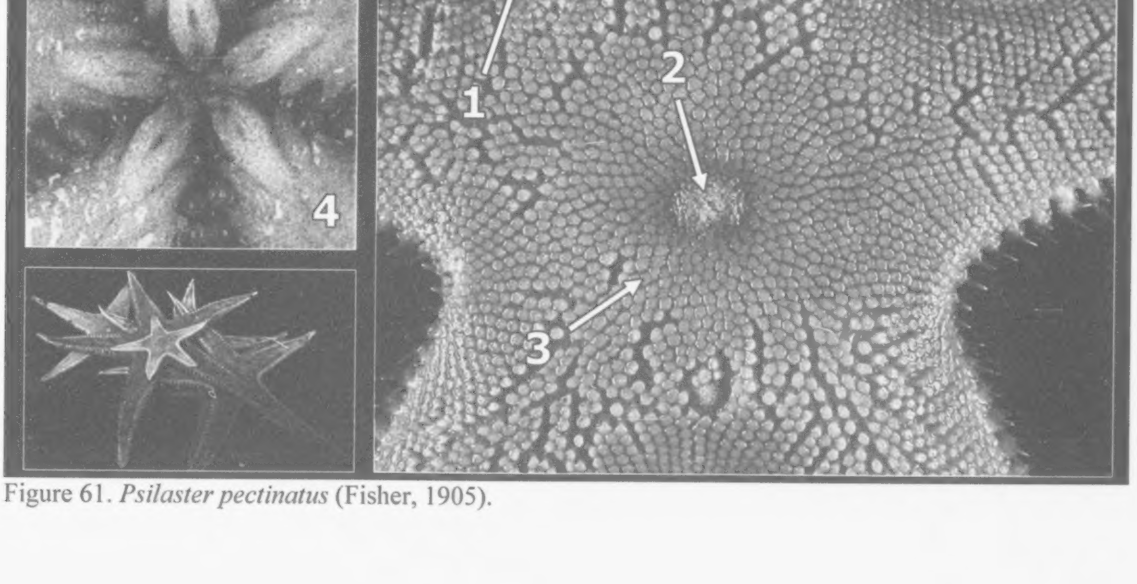
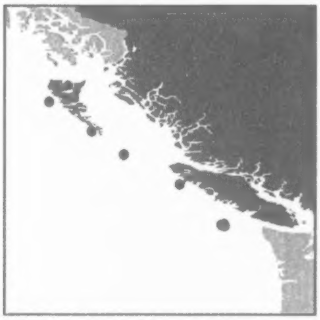


Figure 61. *Psilaster pectinatus* (Fisher, 1905).



Thrissacanthias penicillatus (Fisher, 1905)

Synonyms: *Persephonaster penicillatus* Fisher, 1905

Diagnostic Characters: Long tapering rays; thirty-nine superomarginals each with a **long stout tapering spine in center (1)** and **one or two smaller spines (2)** beside it. Paxillae of aboral surface in **regular oblique transverse rows (3)**, each with a cylindrical paxilla crowned with a brush-like group of eight to twelve slender needlelike spines longer than the paxilla. Papulae on aboral surface except at tip of ray.

Material Examined: Nine specimens in eight lots from 538 – 1250 m between Juan de Fuca Strait and off Skidegate Channel, Haida Gwaii.

Type Locality: Albatross 4380, off Los Coronados Islands, Baja California, southwest of San Diego, California (32° 26' N, 117° 18' W), 530-638 fms (970 – 1167 m), grey sand, green mud.

Previous Known Distribution: Washington to Lower California; 507 – 1503 m (Fisher 1930); 55 (probably an error) – 1500 m (A.M. Clark 1989).

New Distribution: Haida Gwaii, BC to Los Coronados Islands, Baja California, 507 – 1503 m.

Remarks: This study extends the northern range of this species to Haida Gwaii, BC from Washington State.

Other References: Fisher (1911).

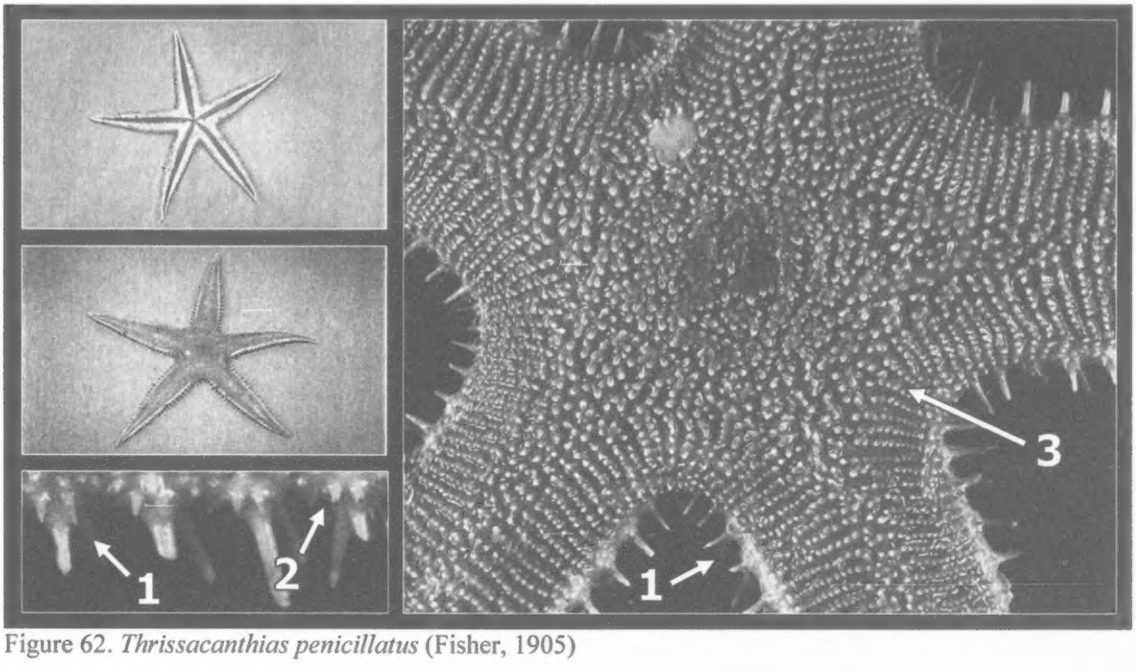
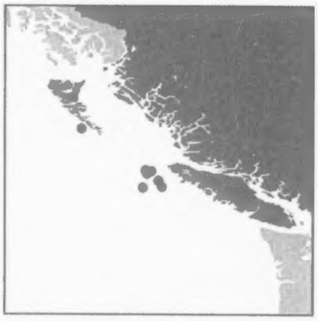


Figure 62. *Thrissacanthias penicillatus* (Fisher, 1905)



Family Porcellanasteridae (Deep-sea Mud Stars)

Eremicaster pacificus (Ludwig, 1905)

Synonym: *Porcellanaster pacificus* Ludwig, 1905;

Diagnostic Characters: Ratio of R = 2.1 r. **Prominent epiproctal cone in centre of disk (1). Three cribriform organs in each inter-radius (2)**; adambulacral plates with **two sharp spinelets (3)**. Eight or nine marginal plates; **superomarginals with one or two upright spinules (4).**

Material Examined: One hundred twelve specimens in eight lots from 1830 – 2300 m between Quatsino Sound, Vancouver Island and Gowgaia Bay, Moresby Island.

Type Locality: Exact locality not stated; description based on specimens from seven stations between latitudes 14° 46' N and 0° 36' S, and longitude 98° 40' W in the region of the Gulf of Panama.

Known Distribution: South of Pribilof Islands, Bering Sea to Gulf of Panama and Galapagos Islands; 1570 – 3436 m (Fisher 1911); off Acapulco, Mexico and Galapagos Is to Bering Sea and Southern Ocean south of India, 1570 – 4090 (A.M. Clark 1989); Bering Sea to Peru, 1571 – 4088 m (Madsen 1961).

Remarks: Within known geographic range of this species.

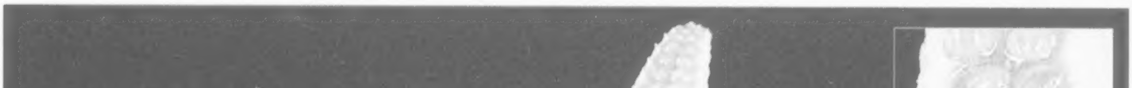
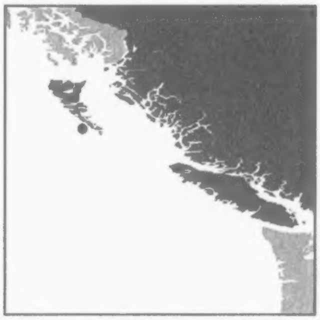


Figure 63. *Eremicaster pacificus* (Ludwig, 1905)



Eremicaster crassus (Sladen, 1883)

Synonyms: *Porcellanaster gracilis* Sladen, 1883; *Porcellanaster waltheri* Ludwig, 1905; *Porcellanaster (Eremicaster) tenebrarius* Fisher, 1905

Diagnostic Characters: Five rays (R=3.45r); abruptly tapering at base. **Superomarginals with 1 or 2 spinules on upper edge (1)**, up to 19 unarmed inferomarginals. **Adambulacral plates with one or two spinelets (2)**; furrows very wide. Aboral area on ray very narrow.

Material Examined: Five specimens in one lot from 2000 – 2300 m southwest of Moresby Island.

Type Locality: Mid South Pacific.

Previous Known Distribution: Mid south Pacific, Indian Ocean; Bering Sea to Peru and Chile and southwest Atlantic off Uruguay; 1570 – 6330 m (A.M. Clark 1989).

Remarks: These specimens fall into the geographic range of *Eremicaster tenebrarius* Fisher, 1905 which has since been synonymized with *Porcellanaster gracilis* by Madsen (1961), which in turn has been considered synonymous with *E. crassus* by Belyaev (1985 as seen in A.M. Clark 1989).

Other References: Fisher (1911).

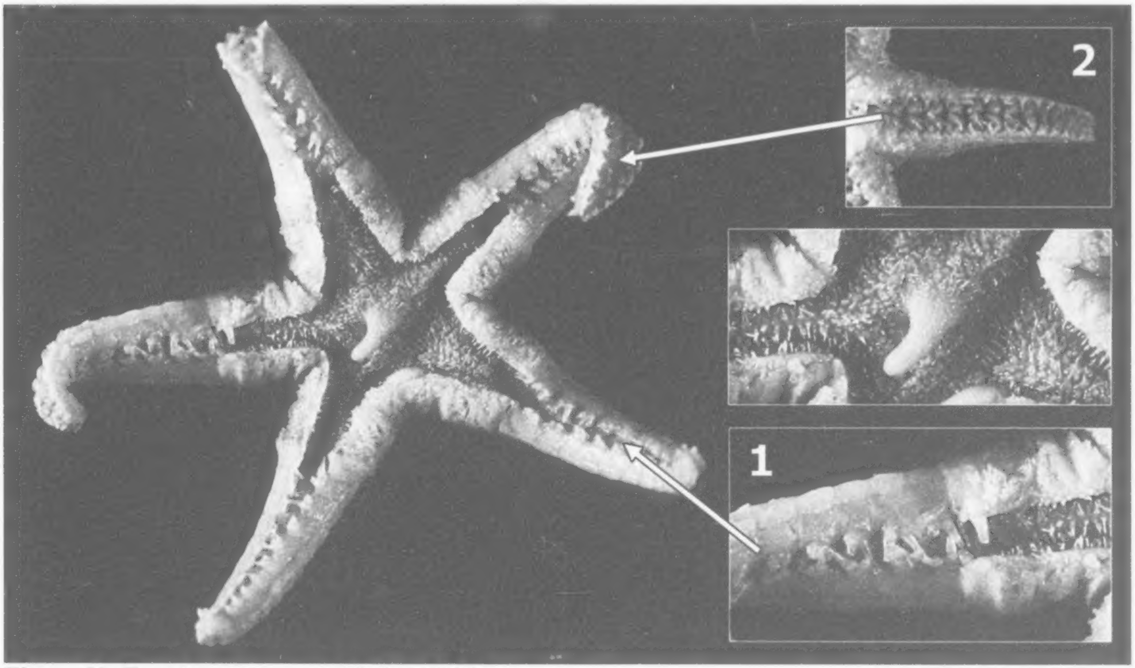
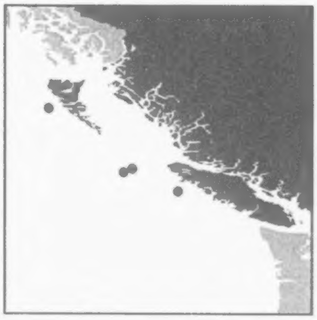


Figure 64. *Eremicaster crassus* Sladen, 1883



Order Notomyotida
Family Benthopectinidae

Benthopecten acanthonotus Fisher, 1905

Diagnostic Characters: Rays narrow, depressed, long and very gradually tapering to tip. Aboral surface with lobed plates bearing a single spine plus one to several small spinelets. Numerous pectinate pedicellariae on aboral surface far along ray. **Papular areas (1)** extending as far as seventh to twentieth superomarginal. **Superomarginals with one spine (2), inferomarginals with two (3)**. Odd inter-radial spine in each inter-radius. Adambulacrals with 4 – 7 **furrow spines (4)** and two much longer oral spines. Inferomarginal plates with pectinate pedicellariae only at base of ray.

Material Examined: Eight specimens in four lots from 1859 – 2125 m between Quatsino Sound, Vancouver Island and Englefield Bay, Haida Gwaii.

Type Locality: Off San Diego California, 1937 m.

Previous Known Distribution: Southern California, 1800 – 1937 m (Fisher 1911); southern California to north coast of Oregon, 1920 m (Alton 1966b).

New Distribution: Southern California to Haida Gwaii, BC, 1800 – 2125 m.

Remarks: Alton found that specimens from Oregon varied from the type in the number of pectinate pedicellariae (fewer) and numbers of spines on adambulacrals and oral plates but were still conspecific with the type. We found similar variations in pedicellariae with BC specimens but they still fit the description for *B. acanthonotus*. This study extends the known range to Haida Gwaii, BC from northern Oregon and slightly deeper to 2125 m.

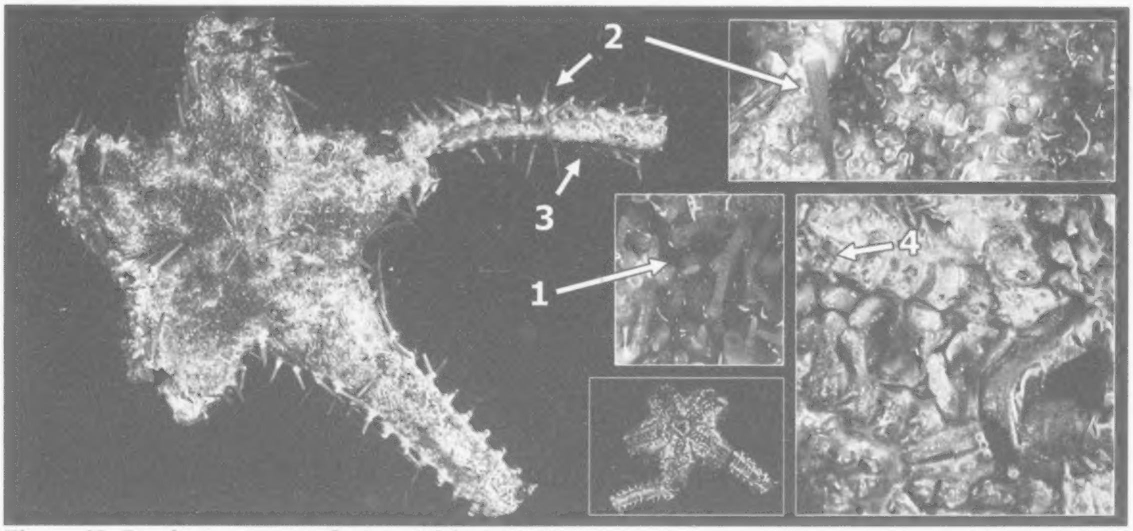
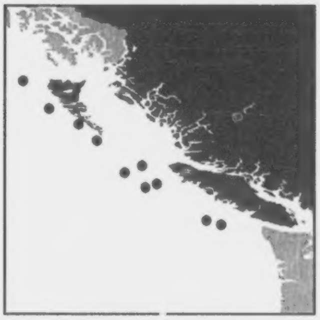


Figure 65. *Benthopecten acanthonotus* Fisher, 1905



Benthopecten claviger claviger Fisher, 1910

Synonyms: *Benthopecten claviger* Fisher, 1910 (A.M. Clark 1989).

Diagnostic Characters: Disk small. Rays long and evenly tapered. Aboral surface with numerous thorny spines surrounded at the base with 8 – 15 **small thorny spinelets (1)**. Odd inter-radial **superomarginal spines (2)** prominent. **Aboral pectinate pedicellariae (3)** present but variable in number. Inferomarginals and adambulacrals with two club-shaped (clavate) spines. Four to six slightly curved **furrow spines (4)**.

Material Examined: Approximately 24 specimens in 10 lots from 1100 – 2400 m between Juan de Fuca Strait and Dixon Entrance.

Type Locality: Albatross 3788, off Cape Blanco, Oregon (43° 1' N, 125° 12' 30" W), 1064 fms (1946 m), green mud.

Previous Known Distribution: Southern Bering Sea to Oregon, 1805 – 1946 m (Fisher 1911); 1646 – 1920 m (Alton 1966b).

Remarks: This study extends the minimum and maximum depth range of this species to 1100 – 2400 m based on collections in BC. A.M. Clark (1989) designated this subspecies to differentiate it from *B. claviger occidentalis* Baranova, 1955.

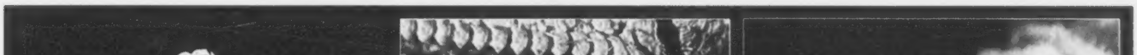


Figure 66. *Benthopecten claviger claviger* Fisher, 1910

Benthopecten mutabilis Fisher, 1910

Diagnostic Characters: A few prominent spines in centre of the disk, others short, stubby and robust; each surrounded by several small spinelets.Usually some of the odd inter-radial marginal plates are paired rather than single. Inferomarginal and aboral pectinate pedicellariae extending far along the ray. Aboral surface with several large spines near centre of disk, each with several small spinelets surrounding. Papulae confined to base of ray and disk.

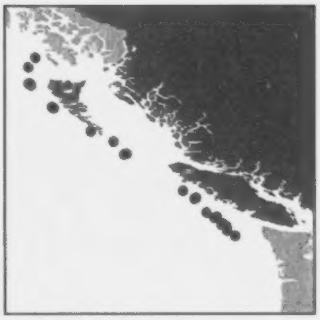
Material Examined: None collected in this study.

Type Locality: Albatross 2859, off Prince of Wales Island, Alaska (55° 20' N, 136° 20' W), 1569 fms (2869 m), gray ooze.

Previous Known Distribution: Only known from the type locality.

Remarks: This species may prove to be a variant of the more common *Benthopecten claviger claviger*.

Other References: Fisher (1911).



Nearchaster aciculosus (Fisher, 1910)

Synonyms: *Acantharchaster aciculosus* Fisher, 1910

Diagnostic Characters: **Slender primary spines (1)** on aboral plates surrounded by 8 – 15 long, slender accessory spines that form a dense armament. A few aboral pectinate pedicellariae. Papulae numerous on disk and to middle of ray. **Superomarginals with 2 or 3 long slender spines (2)** surrounded by 7 – 12 auxiliary spinules; **inferomarginals similar (3)**. Odd inter-radial marginal plates in one to five inter-radii, usually three or four. Adambulacrals with 2 – 4 furrow spinules and 2 or 3 **long slender spines on oral surface (4)**.

Material Examined: Approximately 150 specimens in 22 lots from 490 – 1240 m between Juan de Fuca Strait and Dixon Entrance.

Type Locality: Albatross 4402, between San Diego and San Clemente Island, California (32° 54' N, 118° 30' W), 991 m, green mud.

Known Distribution: South of Alaska Peninsula to northern Baja California; 549 – 1463 m (Fisher 1911); 84 – 1463 m (Lambert 1999); 532 – 1490 m (Alton 1966b).

Remarks: BC specimens well within the known geographic distribution.

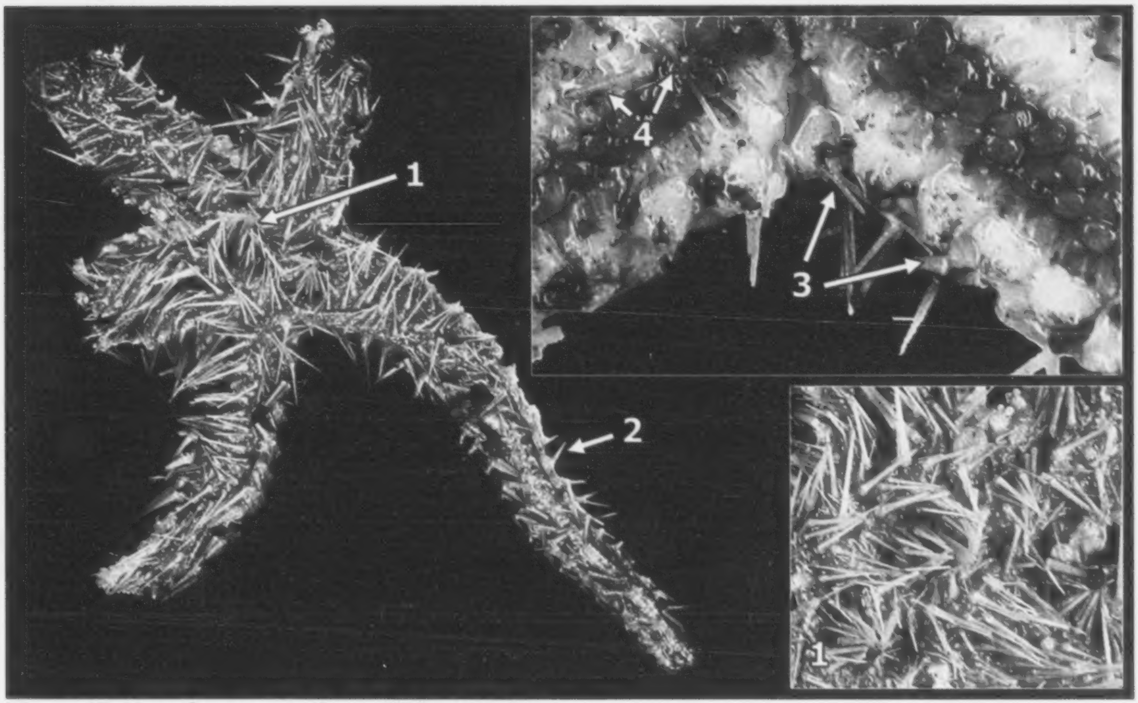
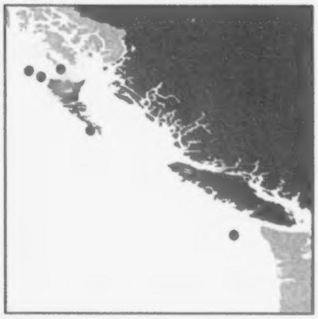


Figure 67. *Nearchaster aciculosus* (Fisher, 1910).



Nearchaster variabilis variabilis (Fisher, 1910)

Diagnostic Characters: Differs from *N. aciculosus* in closer fitting aboral plates; reduction of **spinules (1)** around **primary spines (2)** to either very short or, if longer, then fewer; four to six furrow spinules; variable extent of papular area to 1/3 – 3/5 length of ray. Spines generally stouter than *N. aciculosus* (Figure 67).

Material Examined: Thirty specimens in five lots from 256 –1061 m between Juan de Fuca Strait and Dixon Entrance.

Type Locality: Albatross 3331, north of Unalaska Island, Alaska, Bering Sea (54° 1' 40" N, 166° 48' 50" W), 350 fms (640 m), mud.

Known Distribution: Southern Bering Sea to southeastern Alaska, 198 – 642 m (Fisher 1911); Southern Bering Sea to Juan de Fuca Strait, 200 – 1061 m (Lambert 1999).

Remarks: Specimens collected in this study are within the previously published geographic limits.

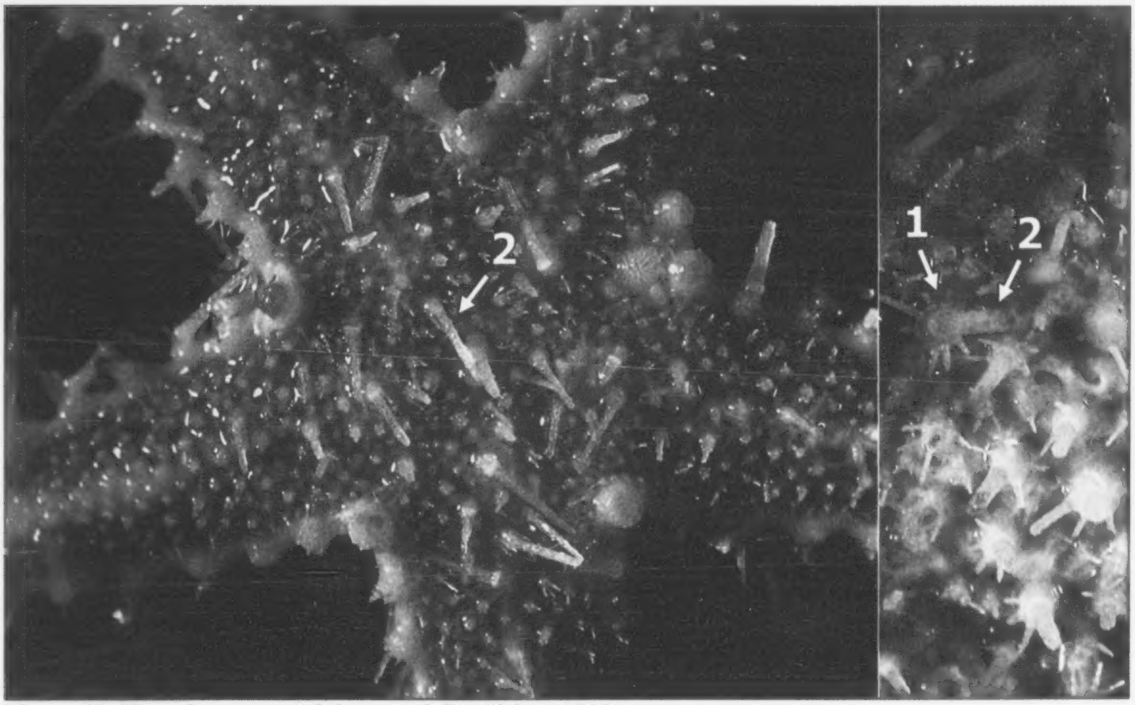
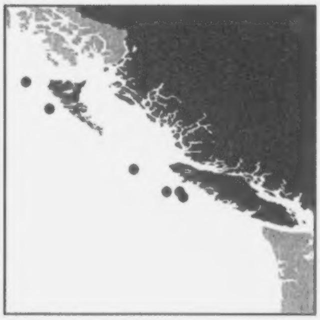


Figure 68. *Nearchaster variabilis variabilis* (Fisher, 1910)



Pectinaster agassizi evoplus (Fisher, 1910)

Synonyms: *Cheiraster agassizi evoplus* Fisher, 1910

Diagnostic Characters: Aboral surface with numerous, small, roundish, low, spaced **paxillae (1)**; larger ones with a delicate central spine and a crown of eight to fifteen small spinelets. Variable number of small pectinate pedicellariae on aboral surface; numerous on oral intermediate areas . Papulae confined to an obvious **oval papularium (2)** at the base of each ray. Adambulacrals with 5 – 9 **furrow spinelets (3)**.

Material Examined: Sixteen specimens in five lots from 1955 – 2200 m between Nootka Sound and Dixon Entrance.

Type Locality: Albatross 4387, off San Diego, California (32° 29' 30" N, 118° 4' 20" W), 1059 fms (1937 m), green mud.

Previous Known Distribution: Southern California, 1800 – 1937 m (Fisher 1911); off the northern coast of Oregon, 1920 m (Alton 1966b); northwest of Haida Gwaii to Nootka Island, BC, 1100 – 2200 m (Lambert 1978b).

Remarks: Records in this study within published geographic limits.

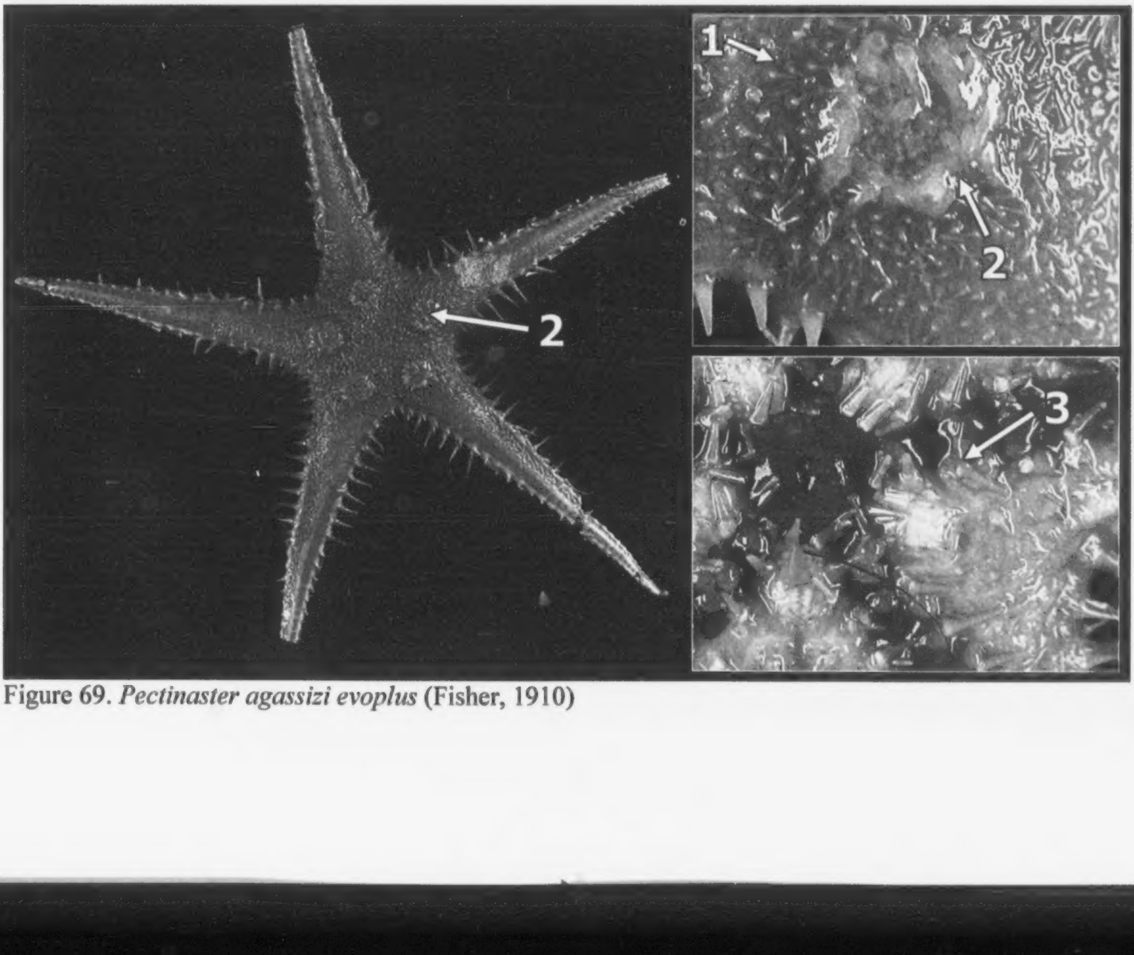


Figure 69. *Pectinaster agassizi evoplus* (Fisher, 1910)

Order Valvatida
Family Goniasteridae

Ceramaster clarki Fisher, 1910

Diagnostic Characters: Resembling ***Ceramaster patagonicus*** **(1)** but margins thinner, marginal plates smaller, last 2 or 3 superomarginals in contact medially (total 14), and **aboral plates (2)** with fewer and larger granules (1 – 6 unequally spaced). **Adambulacral plates (3)** narrow, slightly longer than wide, with a furrow series of 4 or 5 long, compressed, blunt spinelets. Behind furrow series, 2 longitudinal series of 2 or 3 much stouter, short blunt spinelets.

Material Examined: None collected in this study.

Type Locality: Albatross 4772, Bowers Bank, Bering Sea (54° 30' 30" N, 179° 14' E), 344 fms (629 m), greenish brown sand.

Previous Known Distribution: Southern Bering Sea to southern California, 611 – 1098 m (Fisher 1930).

Remarks: Fisher (1911) described the species from the Bering Sea specimen and recorded a juvenile from California , so it is not a well defined species and may turn out to be an aberrant form of another species. Not collected in BC but given the wide range reported, we include it here.

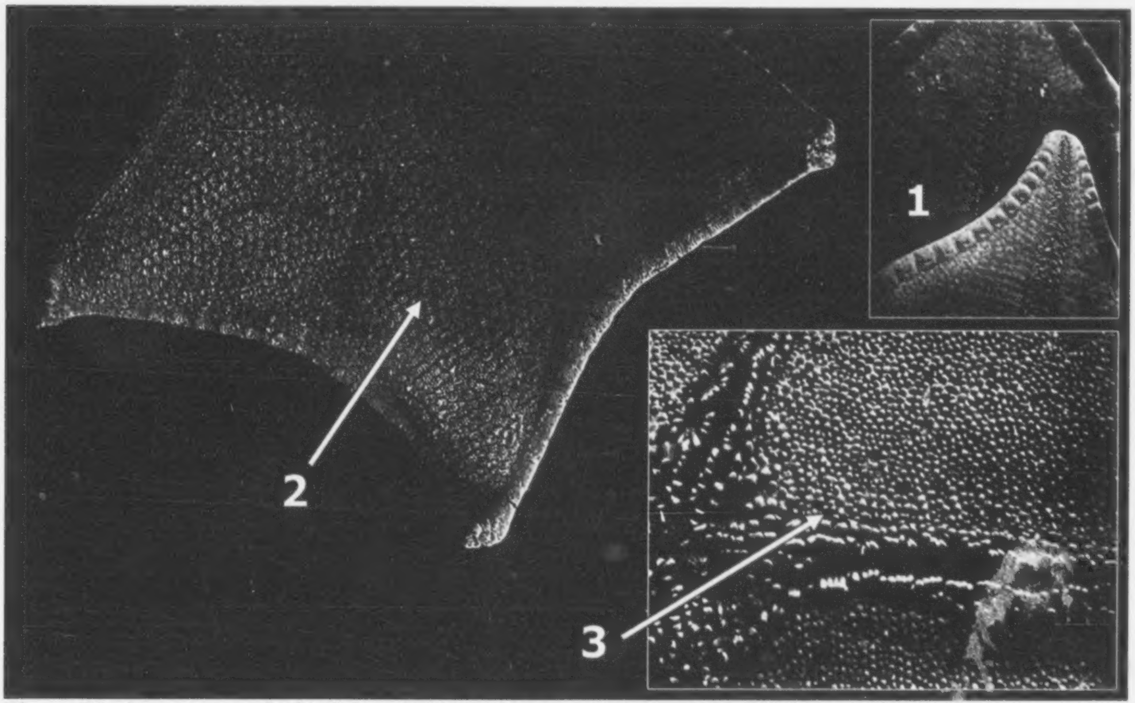


Figure 70. *Ceramaster clarki* Fisher, 1910, with *C. patagonicus* (1), after Fisher (1911).

Ceramaster japonicus (Sladen, 1889)
Japanese Cookie Star

Synonyms: *Pentagomaster japonicus* Sladen, 1889

Diagnostic Characters: Largest *Ceramaster* (R=102 mm). Well spaced **hexagonal to quadrate tabulate plates (1)**, covered with convex granules. Bivalve pedicellariae with thin jaws higher than wide. Edges of the body thickened, **radial areas of aboral side swollen (2)**. A bare space sometimes present on supero- and inferomarginal plates. Adambulacrals slightly wider than long with oblique furrow series of 5 or 6 round-tipped four-sided spinelets, actinal surface with 3 – 5 series of low granules, with a bivalve pedicellaria on each plate.

Material Examined: None collected in this study.

Type Locality: Challenger Station 232, south of Yokohama, Japan, 631 m, green mud.

Previous Known Distribution: Japan to southern Bering Sea, south to Oregon, 195 – 1438 m (Fisher 1911).

Remarks: No known records for BC and only one lot of four specimens from Oregon on this coast.

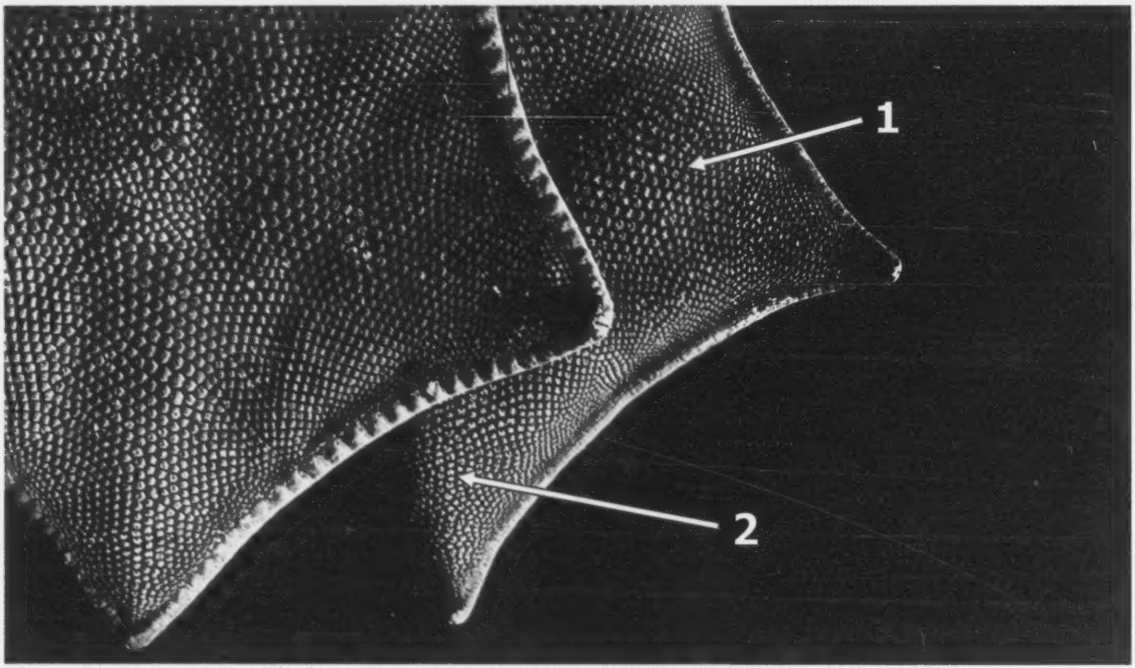
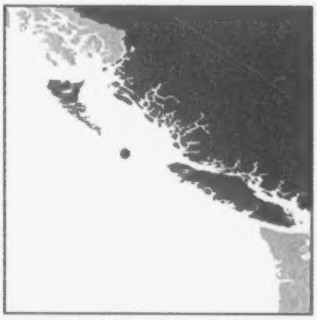


Figure 71. Japanese Cookie Star, *Ceramaster japonicus* (Sladen, 1889), after Fisher (1911).



Cladaster validus Fisher, 1910

Diagnostic Characters: Pentagonal disk with **slightly convex aboral surface (1)**; broad marginals with tumid naked aboral surface; regular aboral plates bearing spaced, **ovoid granules (2)** and small, spatulate pedicellariae; two **furrow spines (3)** and one larger club-shaped **subambulacral spine (4)**.

Material Examined: One specimen at 571 – 621 m in Queen Charlotte Sound.

Type Locality: Albatross 3480, Amukta Pass, Aleutian Islands (52° 6' N, 171° 45' W), 283 fms (518 m), black sand, coral, rocky.

Previous Known Distribution: Previously known from one specimen at the type locality (Fisher 1911). Seven lots collected in the Aleutian Islands region between 116 and 232 m are also deposited in the California Academy of Sciences (C. Mah pers. comm.).

New Distribution: Aleutian Islands south to Queen Charlotte Sound, 116 - 621 m.

Remarks: This study extends the range south to Queen Charlotte Sound, BC at a new maximum depth of 621 m.

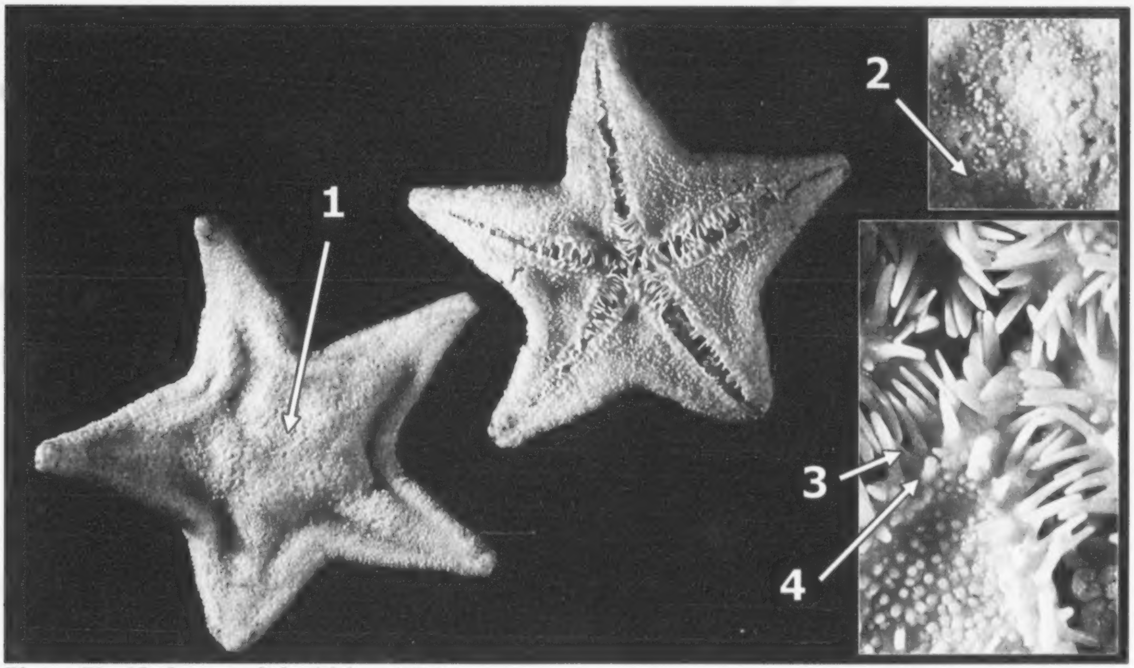
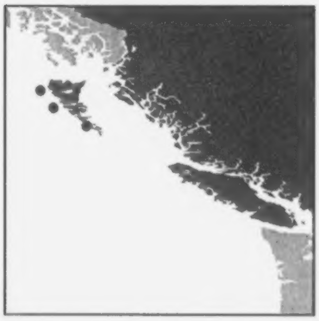


Figure 72. *Cladaster validus* Fisher, 1910



Cryptopeltaster lepidonotus Fisher, 1905

Diagnostic Characters: Resembling a *Hippasteria* (Figure 74) in general shape but with very few spines. Aboral surface inflated on radial areas of the disk and rays. Circular or elliptical aboral plates covered with flattened irregular granules, **low conical spines (1)** and **low bivalve pedicellariae (2)**. Marginal and oral plates covered with flat granules; each supero- and inferomarginal plate bears one **tubercular spine (3)**. Adambulacrals with two thick **furrow spines (4)** or sometimes a **large pedicellaria (5)** and one aboral spine beside the furrow series.

Material Examined: Three specimens in three lots from 896 – 1192 m between southern and northern Haida Gwaii.

Type Locality: Albatross 4430, off Santa Cruz Island, California (33° 57' 2" N, 119° 49' 28" W), 281 fms (514 m), black sand, pebbles, rocks.

Known Distribution: Vicinity of Santa Cruz Island, California to Tres Marias Islands, Mexico, 486 – 1244 m (Fisher 1930); west side of Haida Gwaii, 1061 m (Lambert 1978b); two specimens off Cape Erimo, Hokkaido, Japan, 870 – 915 m have been ascribed to this species but the authors indicated that further study was required to determine if the specimens were anomalous forms of *C. lepidonotus* or a new species (Imaoka et al. 1991).

Remarks: This study adds two more specimens to the one mentioned in Lambert (1978b) in the waters of northern BC.

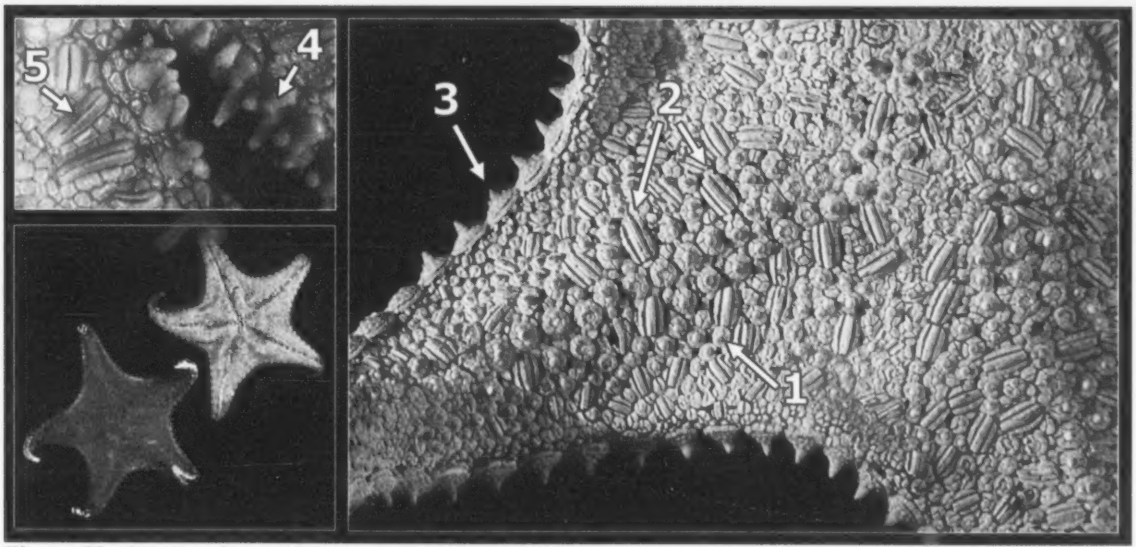
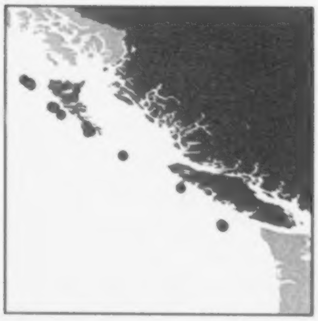


Figure 73. *Cryptopeltaster lepidonotus* Fisher, 1905



Hippasteria californica Fisher, 1905

Diagnostic Characters: Spines on aboral surface but fewer than *H. spinosa*. **Marginal plates (1)** small, elliptical, often separated by encroaching aboral or oral intermediate plates, and typically with one conspicuous spine. Granules around marginals rugose as if covered with minute knobs and points. **Adambulacral plates (2)** with one furrow and one oral spine and usually a broad, high bivalve pedicellaria. Aboral pedicellariae with rounded serrate jaws usually wider at the tip than the base; oral pedicellariae with broad base tapering to a narrow truncate tip.

Material Examined: Thirty-four specimens in 20 lots from 705 – 2014 m between Juan de Fuca Strait and Dixon Entrance.

Type Locality: Albatross 4429, off Santa Cruz Island, California, 506-680 fms (925-1244 m), green mud, black pebbles, shells. (Ahearn 1995, Fisher 1911)

Previous Known Distribution: Southern California to Washington, 486 – 1549 m (Fisher 1911); off Oregon, 411 m (Alton 1966b); southern California to northwest tip of Haida Gwaii, 300 – 2200 m (Lambert 1978b).

Remarks: This study adds more specimens from BC waters. *H. californica* was observed and collected from the coral *Primnoa* (see inset photo). Mah (2010) states that members of the Hippasterinae regularly feed on deep-sea corals.

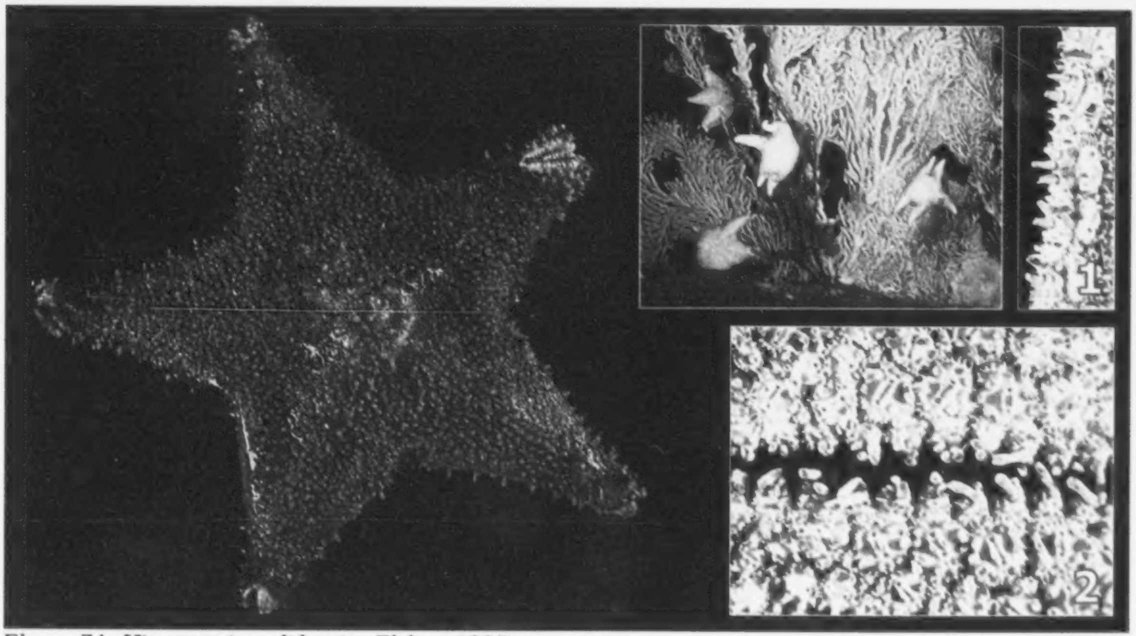
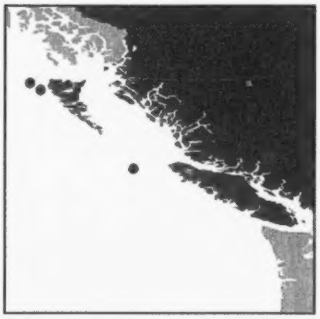


Figure 74. *Hippasteria californica* Fisher, 1905.



Mediaster tenellus Fisher, 1905

Diagnostic Characters: Disk large and flat; rays tapering abruptly near base then more gradually. **Aboral surface (1)** inflated on radial areas sunken on interradial areas. Marginal plates small, almost confined to sides of body. **Aboral plates (2)** tabulate with crown of numerous prismatic spinelets and often an upright two-jawed pedicellaria. **Adambulacral plates (3)** with five long, strongly compressed furrow spinelets and three spinelets on oral surface.

Material Examined: Seven specimens in three lots from 1080 to 2125 m between Cape Scott, Vancouver Island and vicinity of Dixon Entrance.

Type Locality: Albatross 4427, off Santa Cruz Island, California (34° 2' N, 119° 31' W), 447-510 fms (818 – 933 m), black mud, rock.

Previous Known Distribution: Southern California; 532 – 933 m (Fisher 1911); northern Oregon coast, 732 – 914 m (Alton 1966b).

New Distribution: Southern California to Dixon Entrance, 532 – 2125 m.

Remarks: This study extends the northern range from northern Oregon to Dixon Entrance and to a maximum depth of 2125 m.

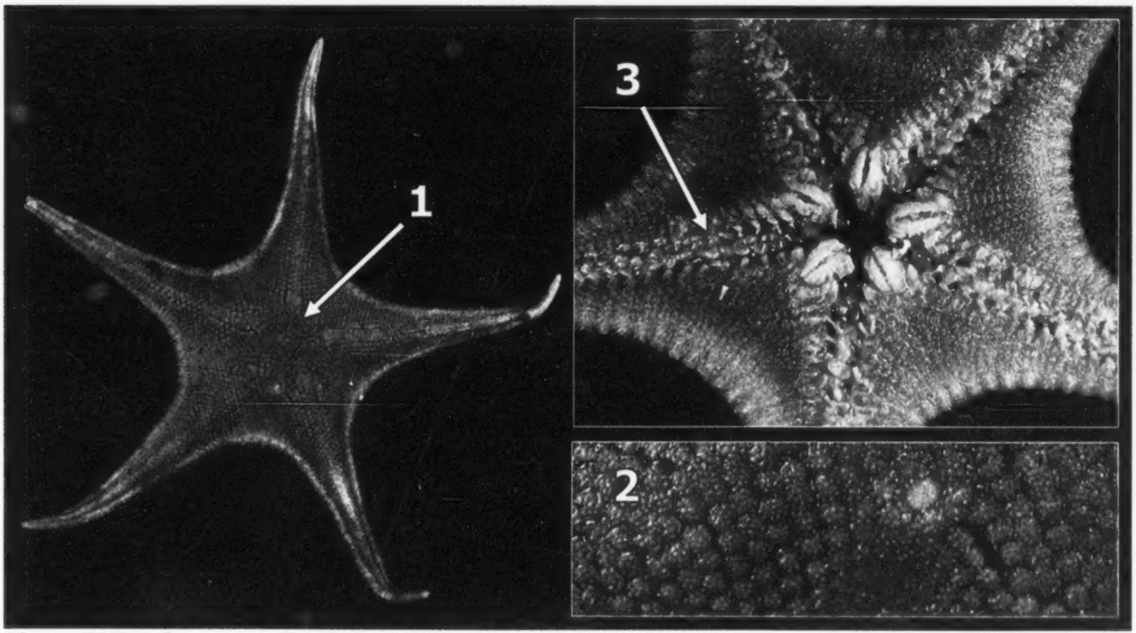
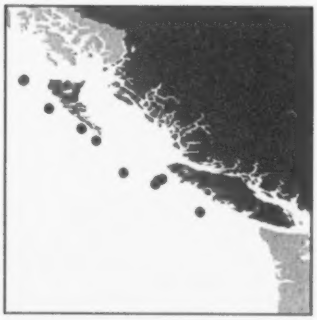


Figure 75. *Mediaster tenellus* Fisher, 1905



Pseudarchaster dissonus Fisher, 1910

Diagnostic Characters: Ratio of arm length to disc radius = 2.6. Rays tapering with straight sides. **Aboral paxillae (1)** large with 15 – 25 central and about the same number of slender, peripheral granules. **Marginal plates (2)** swollen and two series difficult to tell apart; covered with thickened papilliform spinelets on upper series and spinelets with 2 – 5 enlarged spinules on lower. **Adambulacral plates (3)** with 6 – 8 furrow spinelets.

Material Examined: Fifty-nine specimens in 12 lots from 846 – 2300 m between central Vancouver Island and Dixon Entrance.

Type Locality: Albatross 3346, off Oregon (45° 30' N, 124° 52' W), 786 fms (1437 m), green mud.

Previous Known Distribution: Bering Sea to Oregon, 1437 – 1946 m (Fisher 1911); northern Oregon, 1555 – 1920 m (Alton 1966b).

New Distribution: Bering Sea to Oregon, 846 – 2300 m.

Remarks: This study extends the minimum and maximum depths.

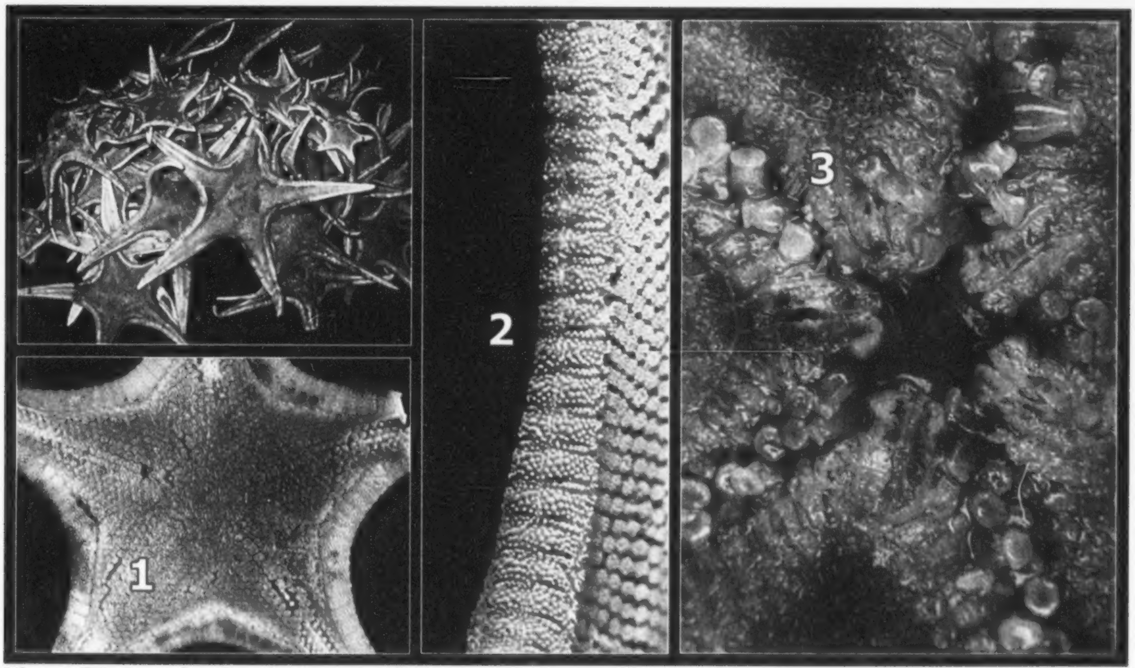
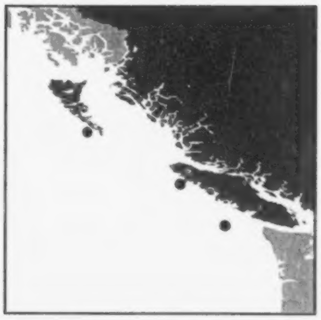


Figure 76. *Pseudarchaster dissonus* Fisher, 1910



Order Velatida
Family Solasteridae

Heterozonias alternatus **(Fisher, 1906)**

Synonyms: *Crossaster alternatus* Fisher, 1906

Diagnostic Characters: Ten rays; R=2.6 – 2.9r. Papulae large, **paxillae well spaced (1)**. Marginal plates of two kinds in a single series, prominent **spiny transverse plates (2)** alternating with two smaller, **horizontal plates with short spinelets (3)**.

Material Examined: Nine specimens in five lots from 725 – 1594 m between Juan de Fuca Strait and Cape St James, Haida Gwaii.

Type Locality: Albatross 2839, Santa Barbara Islands, California (33° 8' N, 118° 40' W), 414 fms (757 m), gray sand.

Previous Known Distribution: Washington to San Diego California, 578 – 1103 m (Fisher 1911); California, 495 – 1200 m (A.M. Clark 1989); north coast of Oregon, 302 – 1555 m (Alton 1966b).

New Distribution: Cape St. James, BC to San Diego, California 302 – 1594 m.

Remarks: This study extends the known distribution north to Cape St. James and the maximum depth to 1594 m.

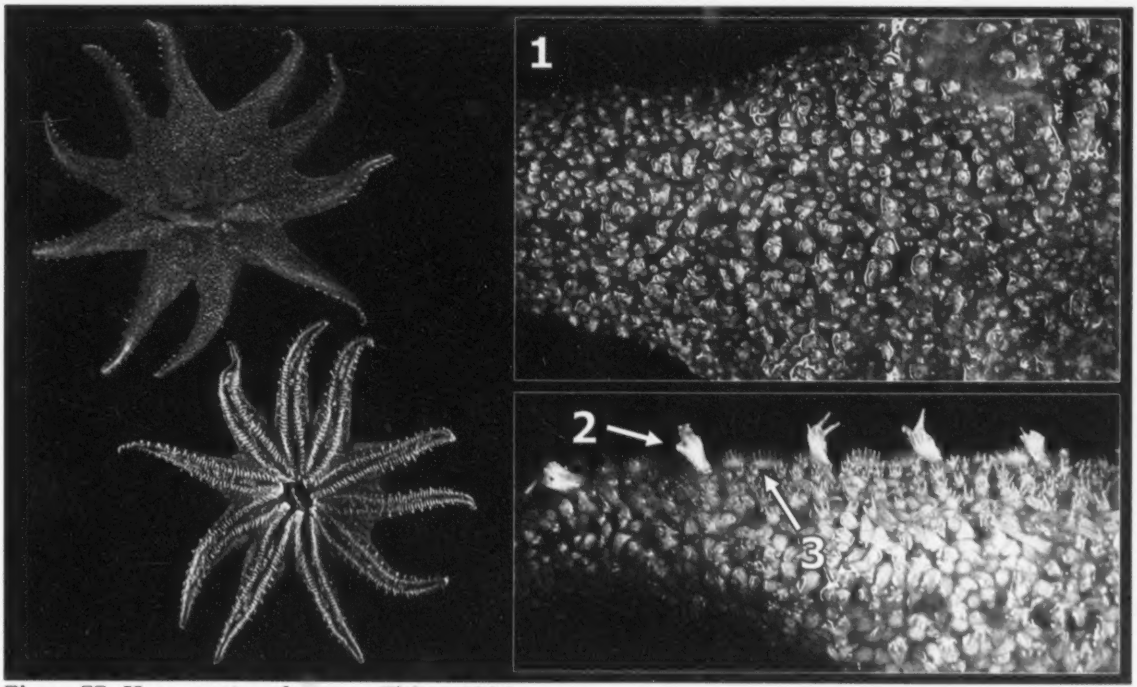
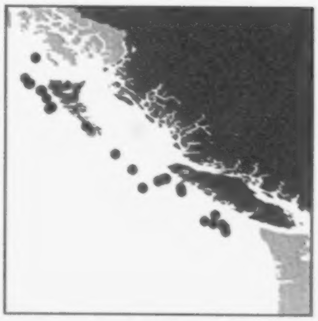


Figure 77. *Heterozonias alternatus* Fisher, 1906



Lophaster furcilliger Fisher, 1905

Diagnostic Characters: R = 4.38r. Rays long and tapering, **ambulacral furrow wide and shallow (1)**, podia with small sucking disk. Aboral surface has well-spaced paxillae on four-lobed plates that form **an open mesh (2)** with 6 – 8 papulae per mesh (2 – 3 in juvenile). Paxillae have tall pedicels with two tufts of long glassy spinelets each bearing 2 – 4 teeth at the tip. Two conspicuous series of marginals.

Material Examined: Fifty-six specimens in 24 lots from 229 – 2125 m between Juan de Fuca Strait and Dixon Entrance.

Type Locality: Albatross 4425, between Santa Barbara Island and San Nicholas Island, California (33° 14' N, 119° 29' W), 1084-1100 fms (1982-2012m), green mud, fine sand.

Known Distribution: South of the Alaska Peninsula to southern California and Galapagos Islands, 351 – 2012 m, green mud, rocks, shells, fine grey sand (Fisher 1911); Bering and Okhotsk Seas (D'yakonov 1950); including form *vexator* 86 – 4200 m (A.M. Clark 1996).

Remarks: Specimens collected in this study are well within the known range of this species. Common in trawls off BC.

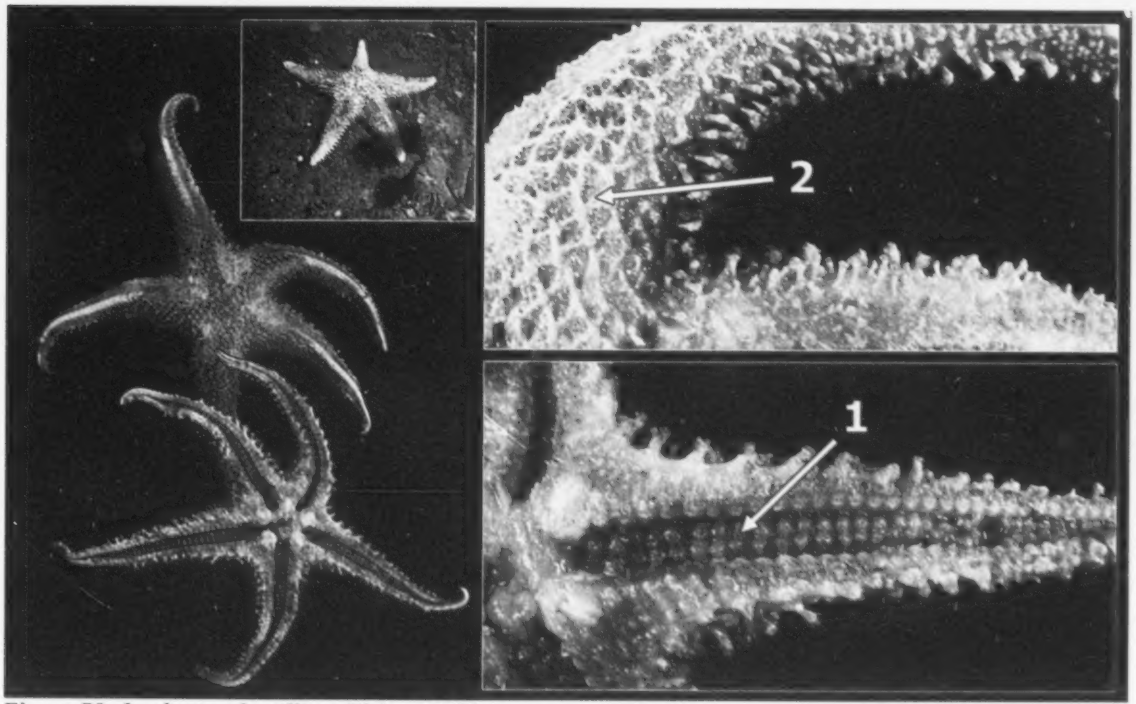
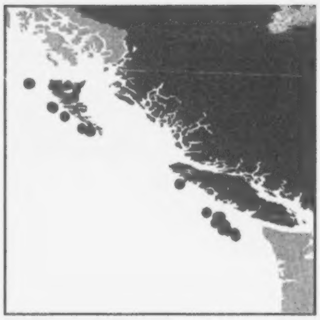


Figure 78. *Lophaster furcilliger* Fisher, 1905



Solaster borealis (Fisher, 1906)

Synonyms: *Crossaster borealis* Fisher, 1906

Diagnostic Characters: Between nine and 12 rays, R = 3r. **Marginal plates (1)** in a single prominent series, paxillae-like with bristling spines. **Papulae (2)** often larger than the aboral paxillae and 3 – 10 per mesh on the disk. A **bare interradial streak (3)** from the angle to halfway to the centre. Adambulacral plates with 5 – 6 **furrow spinelets (4)**, and 2 – 5 much longer **actinal spines (5)** in a transverse series.

Material Examined: At least 65 specimens in 22 lots from 494 – 2300 m between Juan de Fuca Strait and Graham Island.

Type Locality: Albatross 2858, east of Kodiak Island, Alaska (58° 17' N, 148° 36' W), 230 fms (421 m), blue mud and gravel.

Previous Known Distribution: San Diego to Bering Sea and Honshu, Japan, 412 – 1909 m (Fisher 1911); 161 – 1910 m Lambert (1999); 302 – 1920 m (Alton 1966b); 320 – 1910 m (A.M. Clark 1996).

New Distribution: San Diego to Bering Sea and Honshu, Japan, 161 – 2300 m.

Remarks: Depth range extension to 2300 m. This study collected seven specimens from 2000 – 2300 m.

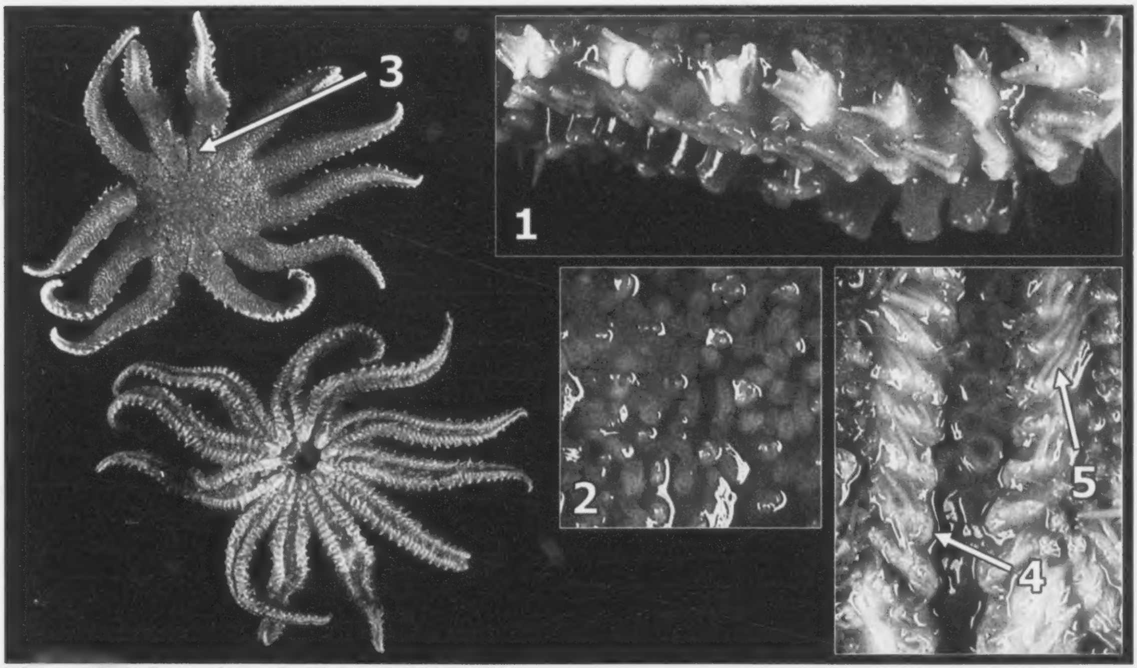
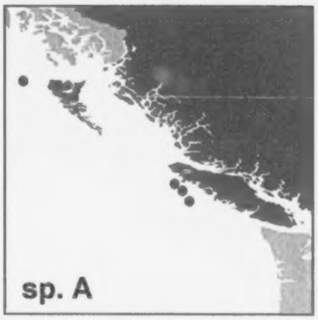
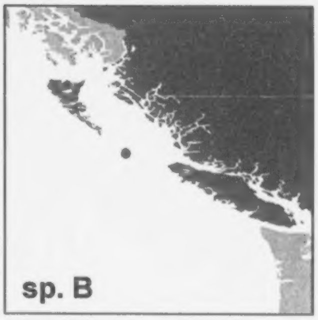


Figure 79. *Solaster borealis* Fisher, 1906





Solaster sp. A
New Genus sp. B

During the course of this study we have collected two other species of *Solasteridae* that appear to be undescribed. One is similar to *Solaster hypothrissus*, and has been designated as ***Solaster* sp. A (1)** by Roger Clark. See his web site at http://www.jaxshells.org/solaster.htm. The other is unlike any other Solasteridae and is considered to be a unique new genus and species. It shall be referred to as ***New Genus* sp. B (2)**, and is being described by Andrew Gale and the senior author.

Material Examined: *Solaster* sp. A: Six specimens in four lots from 1291 – 2083 m between central Vancouver Island (49° 20`) and Dixon Entrance (54° 5`N). *New Genus* sp. B: Four specimens in one lot in Queen Charlotte Sound (51° 12`N, 130° 2.7`W) from 571 – 621 m.

Remarks: Descriptions of these two species will be published in the future.

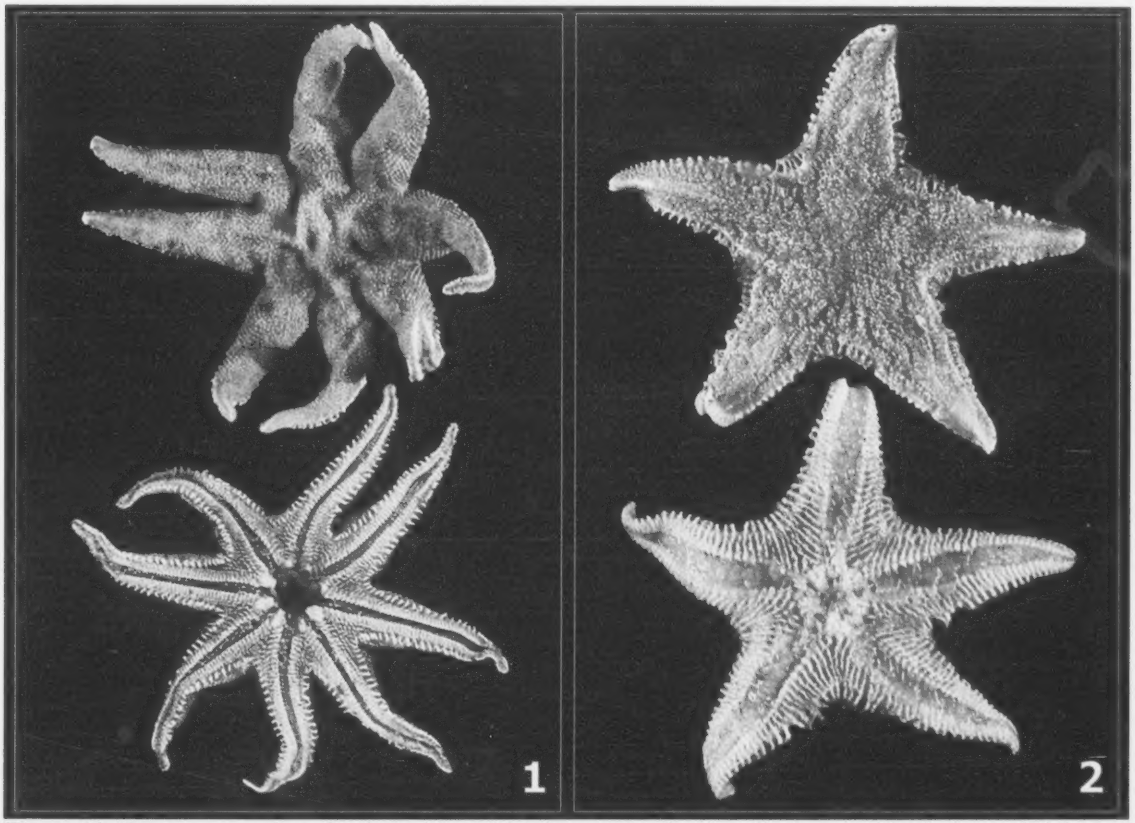


Figure 80. Two new species of Solasteridae which have yet to be described: currently designated *Solaster* sp. A (1) and *New Genus* sp. B (2).

Family Pterasteridae (Cushion Stars)

Hymenaster koehleri **Fisher, 1910**

Diagnostic Characters: Differs from *H. perissonotus* (Figure 82) and *H. quadrispinosus* (Figure 83) in the single adambulacral spinelet; paxillae forming special raised areas; spiraculae numerous (10 – 100) and small in irregular areas surrounded by a fold of skin or sunken.

Material Examined: None collected in this study.

Type Locality: Albatross 3603, Bering Sea between Pribilof Islands and Unimak Island, Alaska (55° 23' N, 170° 31' W), 1171 fms (3239 m), blue ooze (Fisher 1911). (Note: there is a discrepancy between Fisher (1771fms) and Albatross station list regarding depth. (Fisher 1911)

Previous Known Distribution: Known only from type locality in the Aleutian Islands.

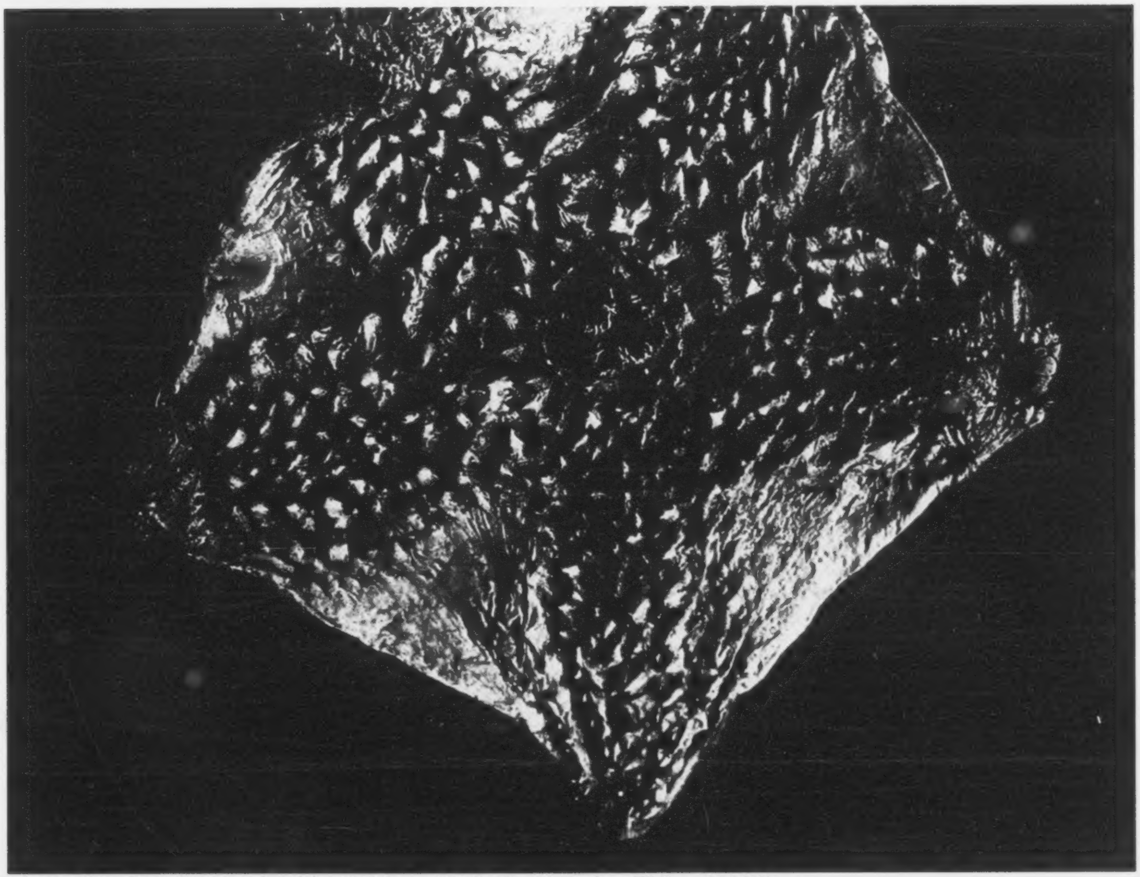
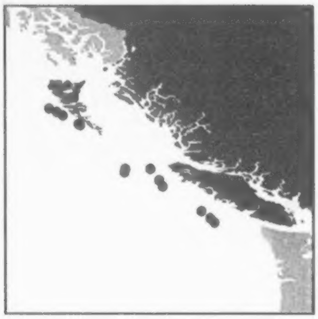


Figure 81. *Hymenaster koehleri* Fisher, 1910. Image after Fisher (1911).



Hymenaster perissonotus Fisher, 1910

Synonyms: According to Clark and Downey (1992) synonymous with *Hymenaster pellucidus* Wyville-Thompson, 1873, a species from the Atlantic.

Diagnostic Characters: Pentagonal shape, R=1.4r; **interradial webs supported by actinolateral spines (1)** which are heavier beyond the middle of the ray. Large scattered spiracula (pores) in the supradorsal membrane, and crisscrossing muscle fibers that radiate from the tips of the paxillar spinelets (3 or 4 per paxilla). Two or three **adambulacral spinelets (2)**. Five or six oral spines, one or two suboral spines.

Material Examined: Fifty-two specimens in 13 lots from 1353 – 2400 m between Juan de Fuca Strait and Moresby Island.

Type Locality: Albatross 2919, west of San Diego, California (32° 17' N, 119° 17' W), 984 fms (1800 m), grey mud.

Known Distribution: Rosario Bay, Baja California to Bering Sea, 412 – 3239 m (Fisher 1930); 1372 – 1920 m Oregon (Alton 1966b); Sea of Okhotsk, on mud (D'Yakonov 1950).

Remarks: In BC, within published depth limits.

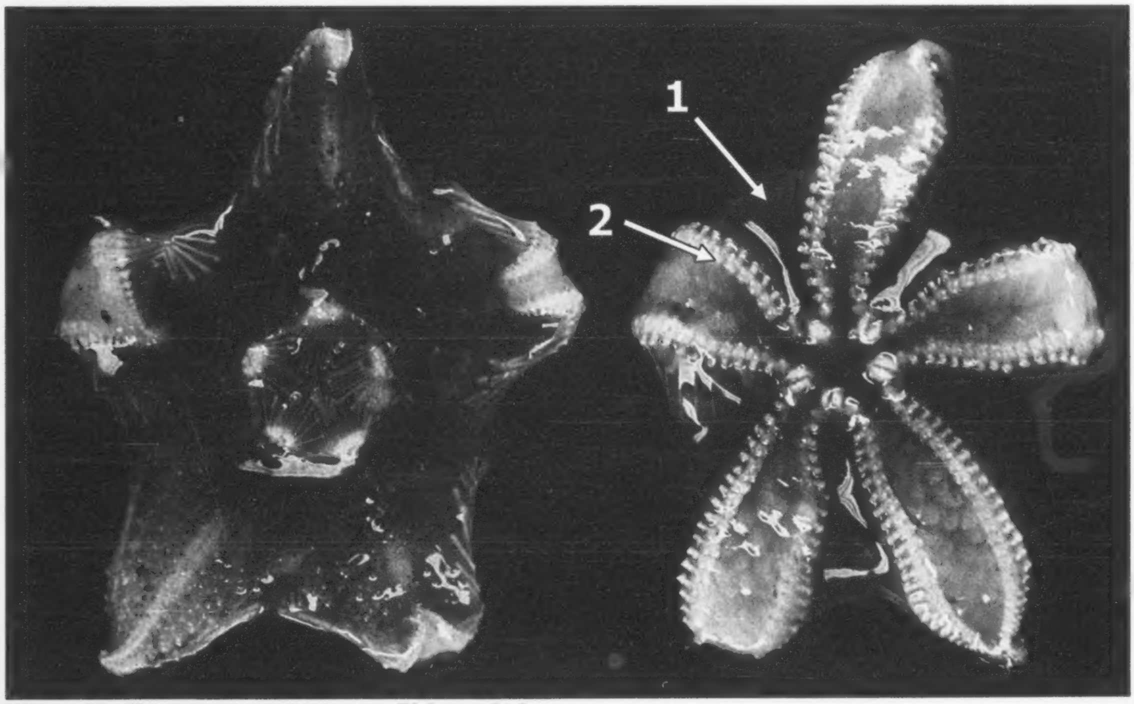
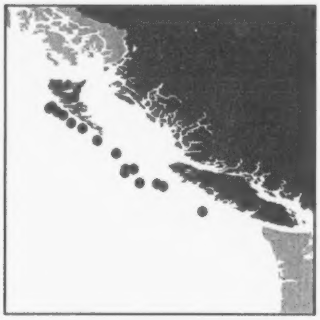


Figure 82. *Hymenaster perissonotus* Fisher, 1910



Hymenaster quadrispinosus Fisher, 1905

Diagnostic Characters: Similar to previous but **4 or 5 adambulacral spines (1)**; 3 or 4 (rarely 5) paxillar spines. **Lateral web extending nearly to tip of ray (2)**. Very numerous small spiracula. Paxilla crowns of adjacent rows alternating.

Material Examined: Thirty specimens in 15 lots from 1225 – 2300 m between Nootka Sound, Vancouver Island and Skidegate Channel, Haida Gwaii.

Type Locality: Albatross 4387, southeast of San Clemente Island, California (32° 29' 30" N, 118° 5' W), 1059 fms (1937 m), green mud (Fisher 1911).

Known Distribution: Off Oregon, 1097 – 1920 m (Alton 1966b); Bering Sea to Panama, 1937 – 3239 m (Fisher 1930); Bering Sea to Panama, Labrador Sea; 1930 – 3610 m (A.M. Clark 1996).

Remarks: Specimens collected in this study are within the previously known distribution.

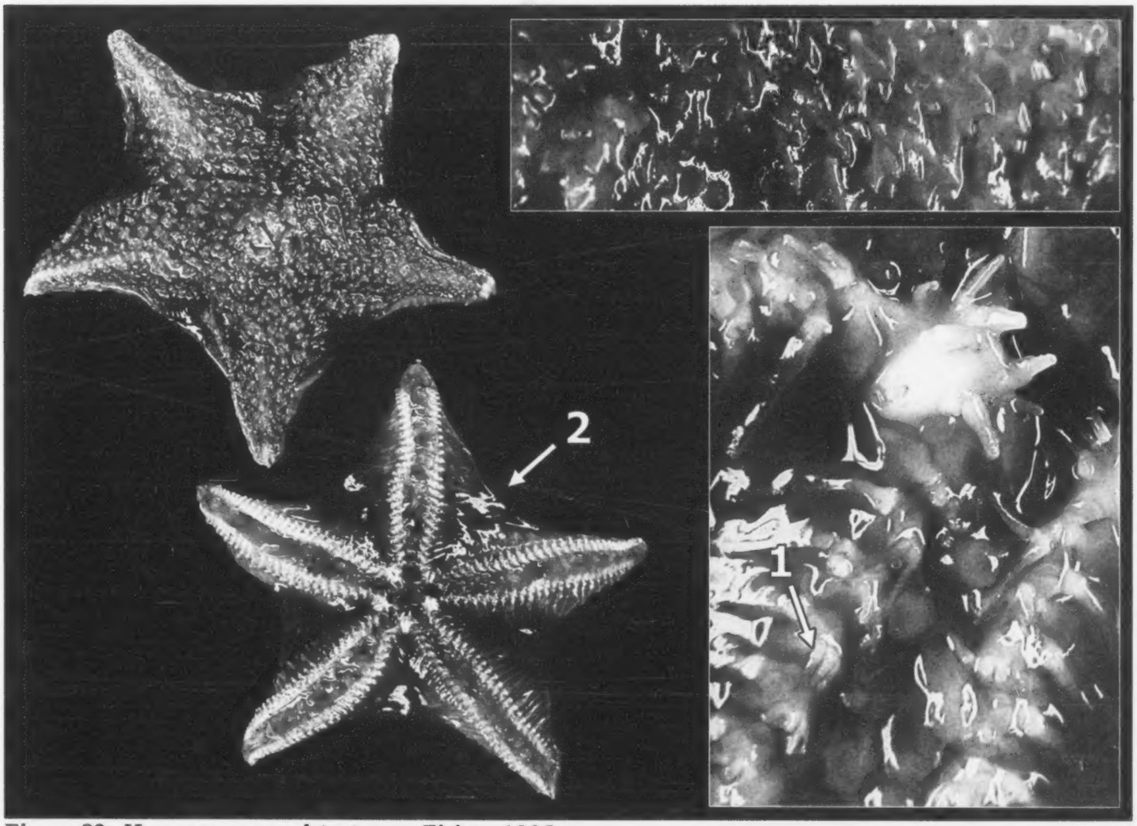
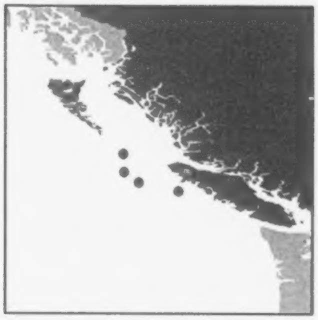


Figure 83. *Hymenaster quadrispinosus* Fisher, 1905



Pteraster coscinopeplus Fisher, 1910

Diagnostic Characters: Form more or less pentagonal (R= 1.4r); **six oral spines (1)**, free (not joined by a membrane); suboral spine very slender; **lateral fringe defining ambitus (2)**; no calcareous deposits in supradorsal membrane; two rows of tube feet.

Material Examined: Seven specimens in four lots from 857 – 1922 m between Kyuquot Sound and Queen Charlotte Sound.

Type Locality: Albatross 2925, off San Diego, California (32° 32' 30" N, 117° 24' W), 339 fms (620 m), mud. (Ahearn 1995, Fisher 1911)

Previous Known Distribution: Off southern and central California; 525 – 1942 m (Fisher 1911).

New Distribution: Southern California to Queen Charlotte Sound, 525 – 1942 m.

Remarks: This study extends the northern range to Queen Charlotte Sound (51 °N) from central California.

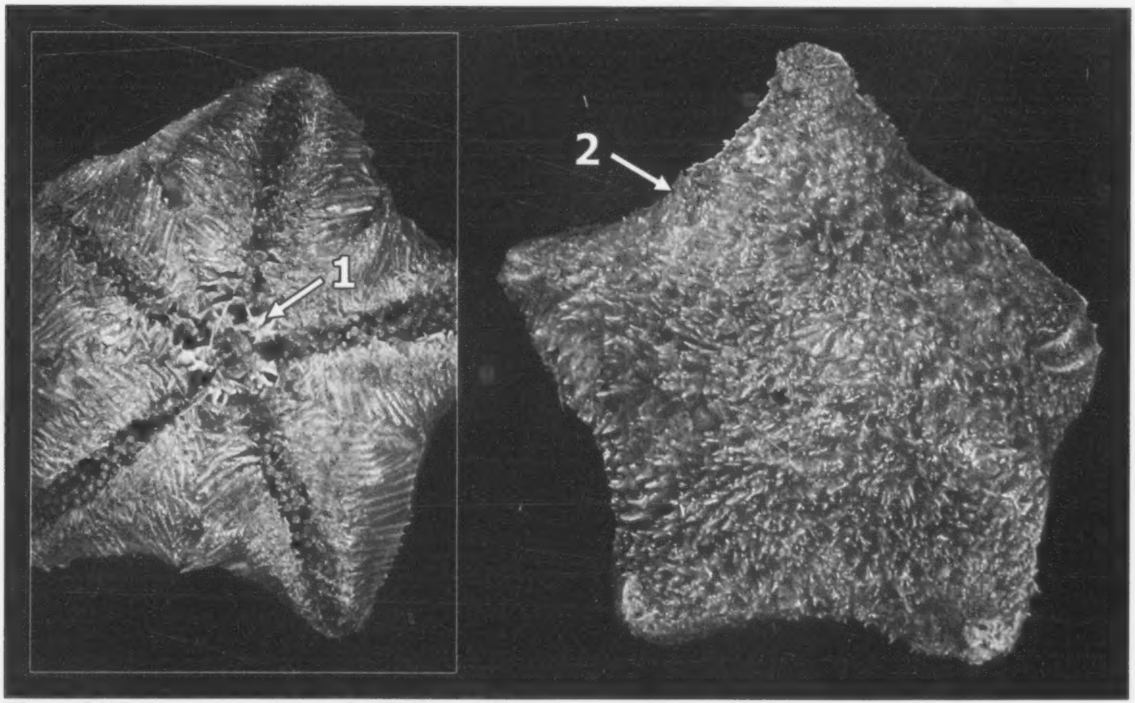
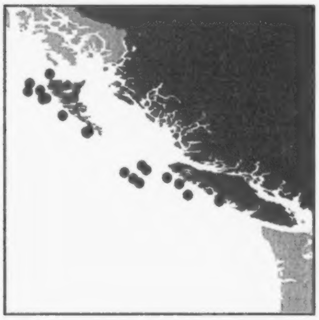


Figure 84. *Pteraster coscinopeplus* Fisher, 1910.



Pteraster jordani Fisher, 1905

Diagnostic Characters: Supradorsal membrane lacking calcareous bodies like in *P. militaris*. Tube feet in four rows (actually 2 staggered rows); three or four adambulacral spines; four mouth spines and one to three paxillar spines. R= 2r.

Material Examined: Thirty-five specimens in 19 lots from 457 – 1903 m between Nootka Sound and Dixon Entrance.

Type Locality: Albatross 4354, off San Diego, California (32° 42’ N, 117° 14’ W), 649 fms (1185 m), green mud.

Previous Known Distribution: Northern Baja California to Washington, 486 – 1800 m (Fisher 1911).

New Distribution: Northern Baja California to Dixon Entrance, 457 – 1903 m.

Remarks: This study extends the northern limit to Dixon Entrance from Washington State and increases the depth range to 457 – 1903 m.

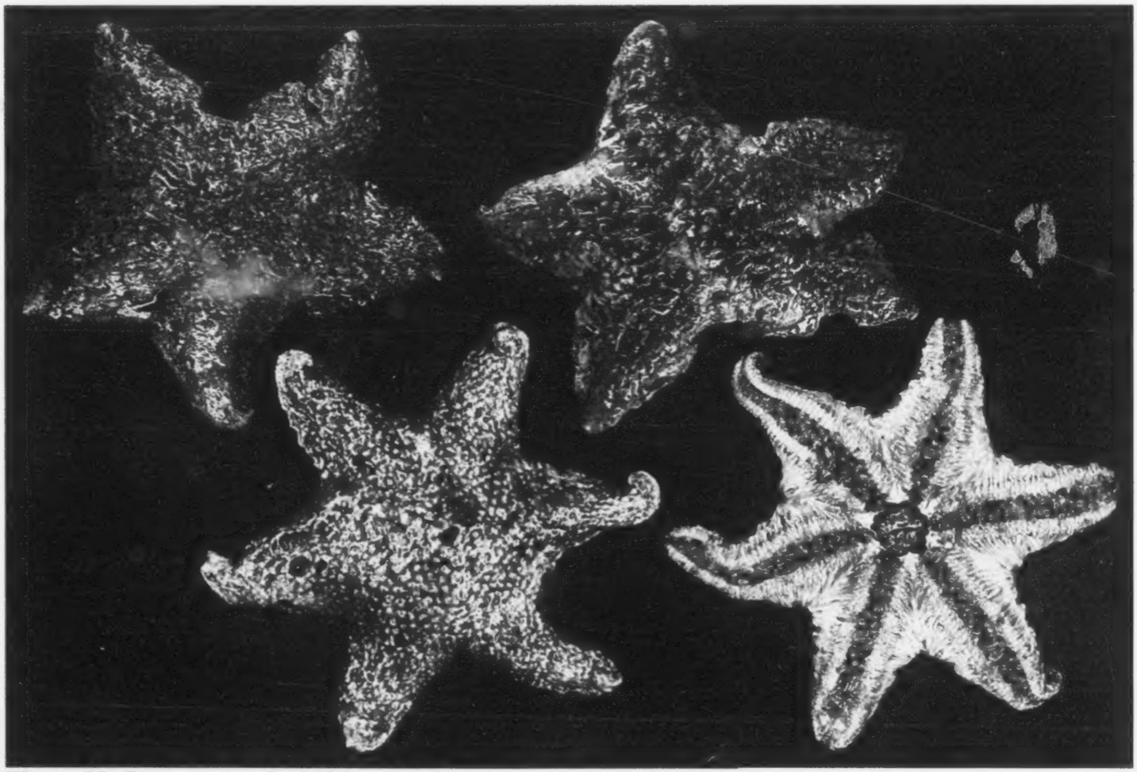


Figure 85. *Pteraster jordani* Fisher, 1905

Pteraster marsippus Fisher, 1910

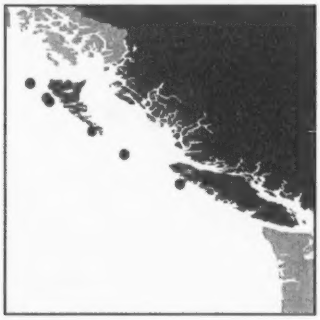
Diagnostic Characters: Three short paxillar spines; sparse calcareous deposits in form of simple rods in the supradorsal membrane; no spiraculae; five adambulacral spines. R=2.5 r.

Material Examined: None collected in this study.

Type Locality: Albatross 4784, near Attu Island, Aleutians (52° 55' 40" N, 173° 26' E), 135 fms (247 m), coarse pebbles.

Previous Known Distribution: Bering Sea and Sea of Japan, 95 – 642 m on gravel (Fisher 1911, D'yakonov 1950).

Remarks: This species resembles *Pteraster jordani* (Figure 85) except for details mentioned above. See Roger Clark web site for photos of fresh specimens (http://www.jaxshells.org/2219.htm).



Pteraster trigonodon Fisher, 1910

Diagnostic Characters: R= 1.87r. **Thin supradorsal membrane (1)** with abundant calcareous deposits in form of irregular spiny rods; numerous spiracula; pseudopaxillae with high pedicels and six divergent spines; **five adambulacral (2)** and five webbed mouth spines; **suboral spine (3)** large, sharp, and three-edged (the species name refers to this feature).

Material Examined: Nine specimens in six lots from 706 – 1259 m between Brooks Peninsula and Dixon Entrance, Haida Gwaii.

Type Locality: Albatross 4427, off Santa Cruz Island, California (34° 2' N, 119° 31' W), 447-510 fms (817 – 933 m), black mud and rocks.

Previous Known Distribution: Known only from the type locality.

New Distribution: Santa Cruz Island to Graham Island, BC (53.6°N), 706 – 1259 m.

Remarks: This study extends the known distribution to waters shallower, deeper and farther north than previously known.

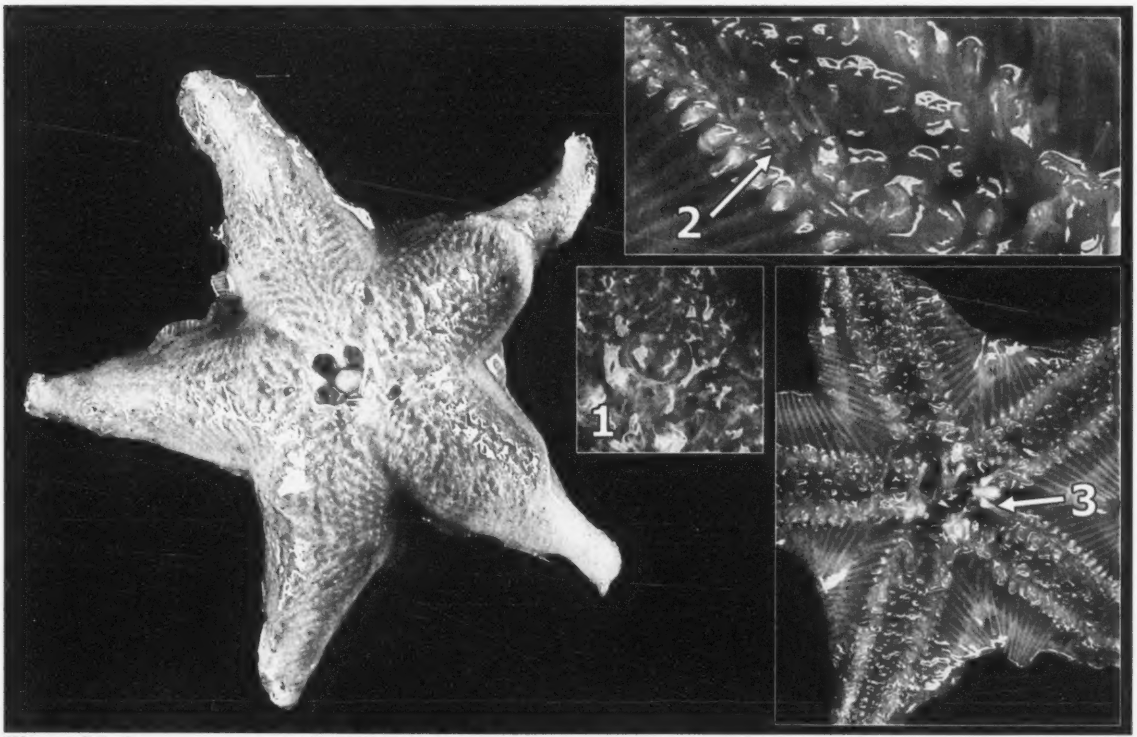
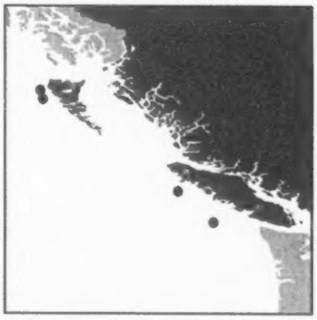


Figure 86. *Pteraster trigonodon* Fisher, 1910.



Family Myxasteridae

Asthenactis fisheri **Alton, 1966**

Diagnostic Characters: Nine or 10 arms; mucous-covered body; no distinct marginal plates; double row of suckered tube feet; adambulacral spines in a semi-circular comb with the concave side facing away from the mouth; the outer 1 – 2 spines of the series are on one adambulacral, the inner (nearest the furrow) 5 – 8 spines are situated on the adjoining plate.

Material Examined: Four specimens from four lots from 1152 – 1922 m between Cape Flattery and Rennel Sound, Haida Gwaii.

Type Locality: Off northwest coast of Oregon (46° 3.2'N), 1464 m (Alton 1966a).

Previous Known Distribution: Only known off Oregon, 1464 m (A.M. Clark 1996).

New Distribution: Northern Oregon to Haida Gwaii, BC, 1152 – 1922 m.

Remarks: Previously only three specimens were known, all from the type locality off Oregon. This study extends the known range to Haida Gwaii, BC and extends the depth range to 1152 – 1922 m.

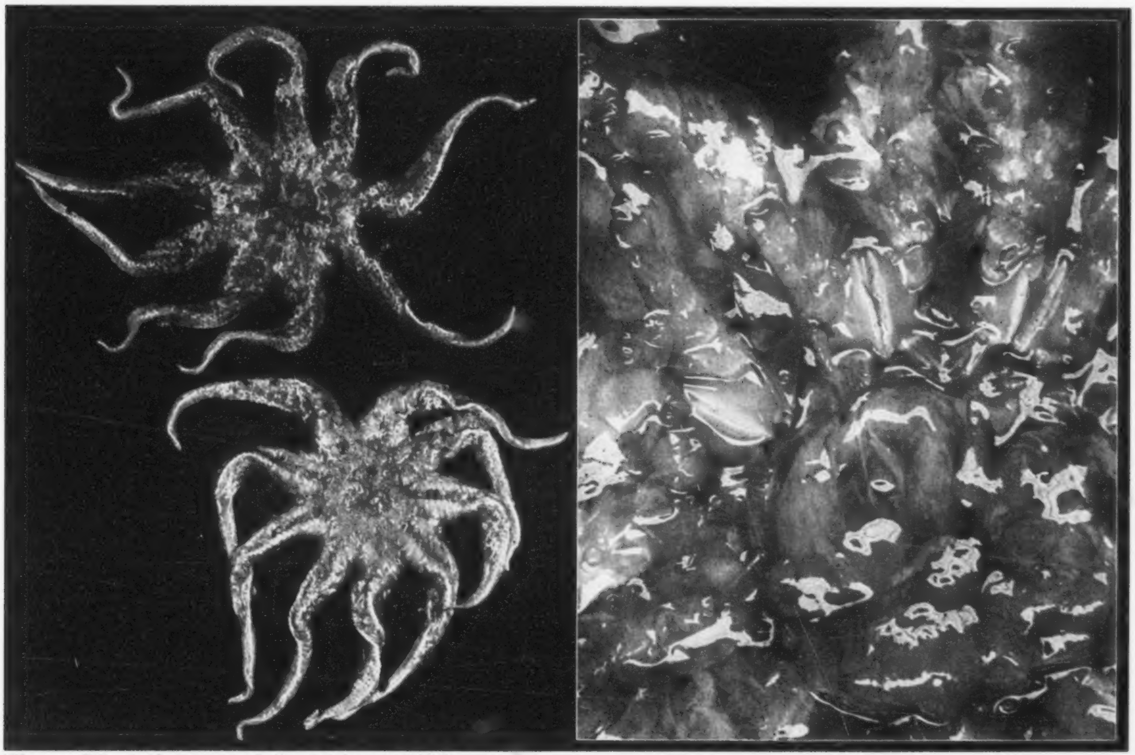


Figure 87. *Asthenactis fisheri* Alton, 1966

Family Korethrasteridae

Peribolaster biserialis Fisher, 1905

Diagnostic Characters: Five short thick arms; disk and arms bristling with tufts of 3 – 5 spinules at the junctions of the netlike skeleton; tube feet in two series; adambulacrals with three spines and with the adjoining single inframarginal, making a transverse series of four.

Material Examined: None collected in this study.

Type Locality: Albatross 4410, between Santa Catalina Island and Santa Barbara Island, California (33° 23' N, 118° 25' W), 178-195 fms (326 – 357 m), gray sand, gravel, and rock (Fisher, 1911).

Previous Known Distribution: Disjunct population known from off San Diego and in the Bering Sea but not in areas in between, 132 – 572 m (Fisher 1911); 104 – 805 m (A.M. Clark 1996).

Remarks: This species occurs north and south of British Columbia so it is included here.

Other References: See images of live specimens collected in the Aleutians by Roger Clark at http://www.jaxshells.org/peribo.htm.

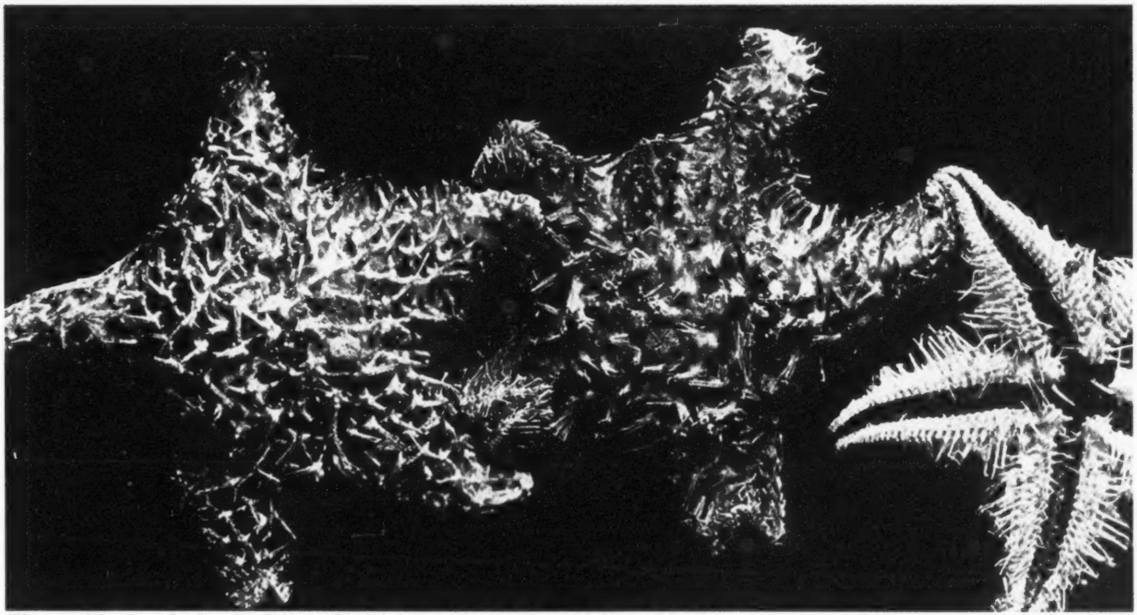
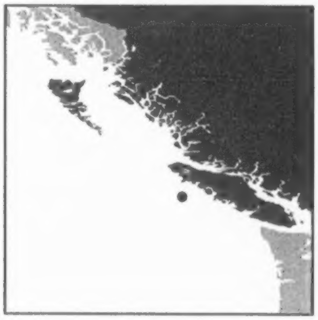


Figure 88. *Peribolaster biserialis* Fisher, 1905 (after Fisher 1911).



Order Spinulosida
Family Echinasteridae

Henricia clarki Fisher, 1910

Diagnostic Characters: Five long, slender, flexible rays; aboral surface depressed; **aboral plates (1)** delicate, forming a sinuous network inclosing smaller secondary plates (a mesh within a mesh); single papulae; **adambulacral plates (2)** with 35 – 40 spinelets on proximal part of ray and two furrow spinelets (except first 6 – 8 plates with 3 – 5 furrow spinelets). No distinguishable series of marginal plates.

Material Examined: One specimen from 1955 m off Vancouver Island (49.911°N).

Type Locality: Albatross 4427, off Santa Cruz Island, California (34° 2' N, 119° 31' W), 475-510 fms (869 – 933 m), black mud and rocks.

Previous Known Distribution: Santa Cruz Island, California to Revillagigedo Islands, Mexico, 227 – 1503 m (Fisher 1911).

New Distribution: Mexico to southeast Alaska, 227 – 1955 m. One specimen off Vancouver Island and Roger Clark (pers. comm.) reports a specimen from 650 m off Prince of Whales Island, Southeast Alaska.

Remarks: Extends the range north from southern California to Prince of Whales Island, Alaska.

Other references: See images by Roger Clark at http://www.jaxshells.org/6518.htm.

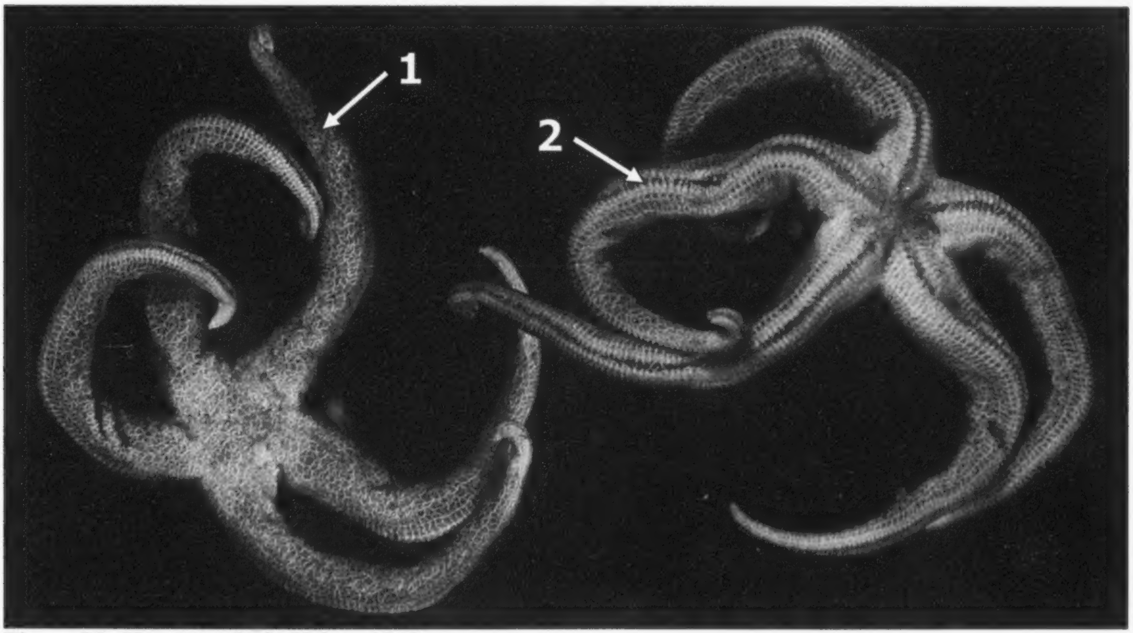
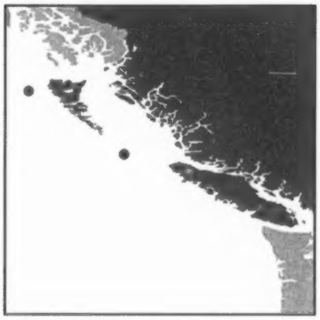


Figure 89. *Henricia clarki* Fisher, 1910



Henricia polyacantha Fisher, 1906

Diagnostic Characters: Five slender flexible rays, aboral surface usually collapsed; **aboral and lateral surfaces with small evenly spaced paxillae (1)**; single large papulae arranged in fairly regular oblique transverse series; very small marginal plates and a regular series of inframarginal papulae; **adambulacral spinelets (2)** very numerous with 2 – 6 furrow spinelets.

Material Examined: Two specimens in two lots from 857 – 1171 m between Queen Charlotte Sound and Graham Island.

Type Locality: Albatross 2936, off San Diego, California (32° 49' N, 117° 27' 30" W); 359 fms (657 m), mud (Fisher 1911).

Previous Known Distribution: Only five specimens in vicinity of type locality, 227 – 657 m (Fisher 1911).

New Distribution: San Diego, California north to Graham Island, BC, 227 – 1171 m.

Remarks: Geographic range extension north from San Diego to Graham Island, BC and maximum depth range extension from 657 m to 1171 m.

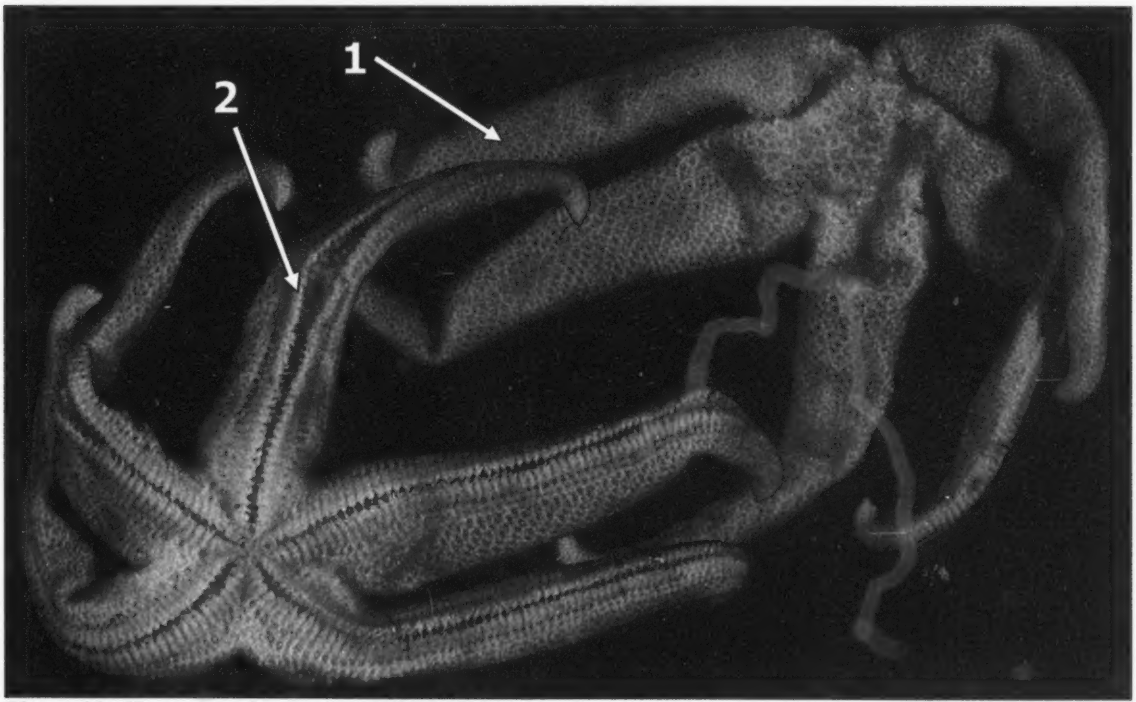
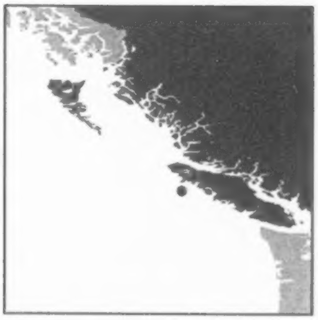


Figure 90. *Henricia polyacantha* Fisher, 1906



Order Forcipulatida (Sea Stars with pedicellariae)
Family Zoroasteridae

Myxoderma sacculatum (Fisher, 1905)

Synonyms: *Zoroaster sacculatus* Fisher, 1905

Diagnostic Characters: Five rays up to 20 cm long; rays sub-cylindrical, stout but slender; tip capped by a swollen conspicuous terminal plate. Aboral skeleton very open with large papular areas with several papulae. All plates with a short stout spine, more per plate aborally. Straight pedicellaria on aboral surface. Plates and spines covered with a slimy jelly-like membrane in life.

Material Examined: One specimen from 1138 – 1170 m off Nootka Sound, Vancouver Island.

Type Locality: Albatross 4517 (Ahearn 1995), off Point Pinos, Monterey Bay, California (36° 38' N, 121° 55' W), 750 fms (1372 m); green mud and sand (Fisher 1911).

Previous Known Distribution: Bowers Bank, Bering Sea and off Monterey Bay and Farallones, 1006 – 1401 m (Fisher 1928); Channel Islands to Bering Sea, 329 – 1678 m (Department of Invertebrate Zoology and Geology, California Academy of Sciences on-line database: http://research.calacademy.org/izg/collections/); Los Coronados Islands, Baja California, to Oregon, 905 – 2012 m (Information provided with the permission of the National Museum of Natural History, Smithsonian Institution, 10th and Constitution Ave. N.W., Washington, DC 20560-0193: http://www.nmnh.si.edu/).

Remarks: First record for BC but within known range.

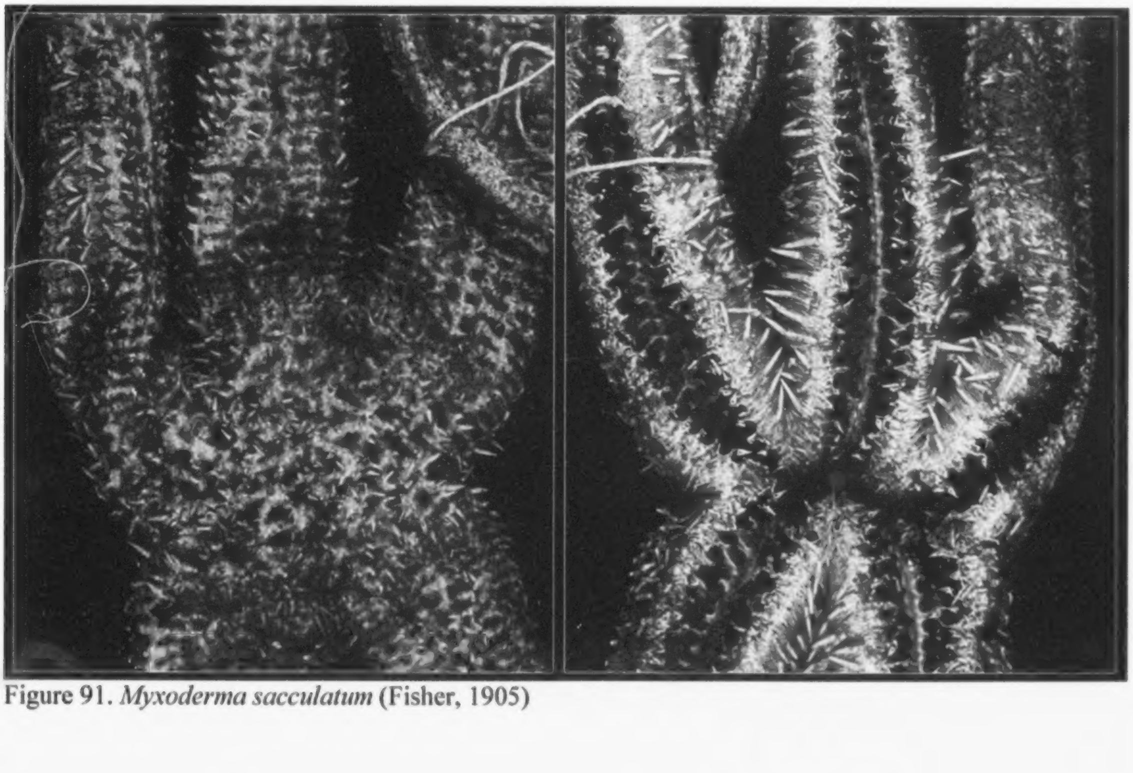
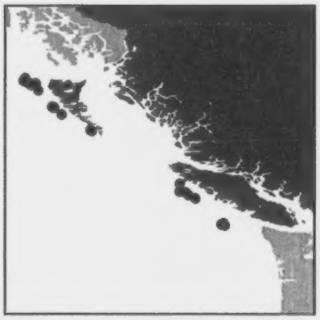


Figure 91. *Myxoderma sacculatum* (Fisher, 1905)



Sagenaster evermanni (Fisher, 1905)

Synonyms: *Zoroaster evermanni* Fisher, 1905 and *Zoroaster evermanni mordax* Fisher, 1919

Diagnostic Characters: Long slender rays, small disk; **aboral, marginal and actinolateral plates in regular longitudinal rows (1)** ; aboral (carinal) row of spines larger than others. Two to four papulae per area. Adambulacral plates alternately carinate (ridged) and non-carinate. No large pedicellariae on second spine of adambulacral plates.

Material Examined: At least 66 specimens in 27 lots from 490 – 2091 m between Juan de Fuca Strait and Dixon Entrance.

Type Locality: *Zoroaster evermani* Fisher, 1905: Albatross 4400, between San Clemente and San Diego, California(32° 50' 20" N, 118° 3' 39" W), 500 – 507 fms (914-927 m), green mud; subspecies *Z. evermanni mordax*: off Washington State (47° 28'N), 760 fms (1390 m) (Fisher, 1911)

Known Distribution: Aleutian Islands (Alaska), Queen Charlotte Islands, Washington to Mexico, 100-2710 m (Mah 2007). Washington to Southern California; 395 – 1390 m (Fisher 1928); north to Skidegate Channel, Haida Gwaii (Lambert 1978b).

Remarks: Mah (2007) created the new genus *Sagenaster* for *Zoroaster evermanni* Fisher, 1905, designating it as the type species of the new genus. He also synonymized it with the subspecies *Z. e. mordax*.

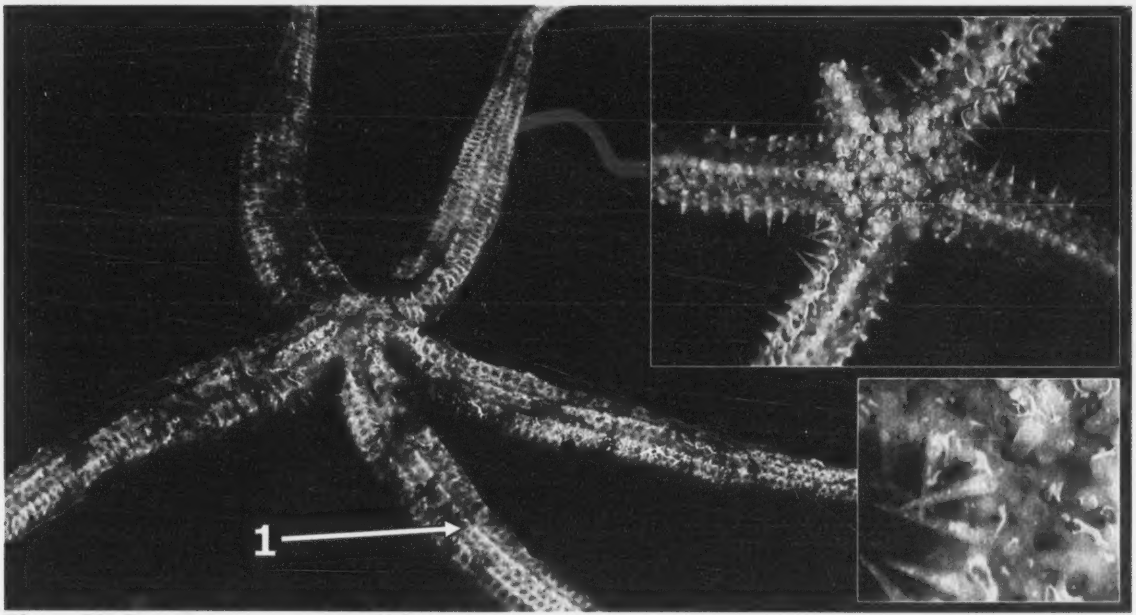
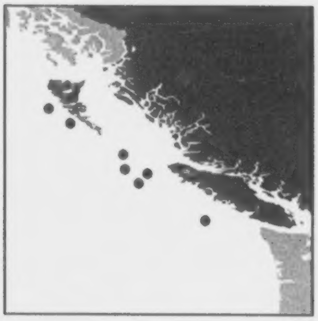


Figure 92. *Sagenaster evermanni* (Fisher, 1905)



Zoroaster ophiurus Fisher, 1905

Diagnostic Characters: Similar in general shape to *Z. evermanni* but the skeletal plates overlap each other like shingles. Four actinolateral series. The prominent adambulacral plates bear a transverse series of 3 – 5 spinelets; the inner one has a membrane with 6 – 8 pedicellariae at the tip; the second bears a single large pedicellaria near the base of the spine.

Material Examined: Fifteen specimens in seven lots from 848 – 2300 m between La Perouse Bank and Englefield Bay, Haida Gwaii.

Type Locality: Albatross 4387, off San Diego, California; 1059 fms (1937 m), green mud (Ahearn 1995)

Previous Known Distribution: Bering Sea to Southern California, 1809 – 2227 m (Fisher 1928); Bering Sea to Northern Peru, 695 – 2230 m (Clark and Mah 2001).

New Distribution: Bering Sea to northern Peru; 695 – 2300 m.

Remarks: This study extends the maximum depth range from 2230 to 2300 m.

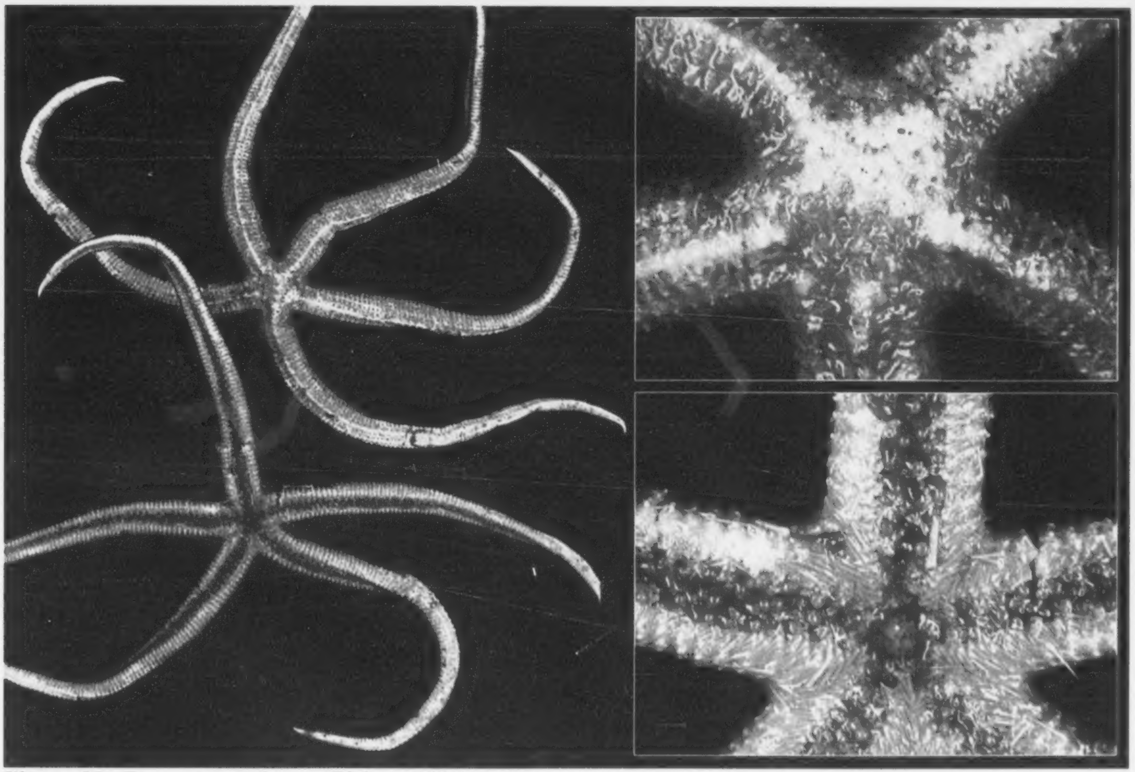
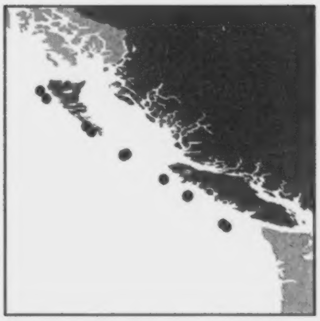


Figure 93. *Zoroaster ophiurus* Fisher, 1905



Family Pedicellasteridae

Ampheraster marianus (Ludwig, 1905)

Synonyms: *Sporasterias mariana* Ludwig

Diagnostic Characters: Adambulacral plates monacanthid (single spine); Tube feet in four rows in a wide **ambulacral groove (1)**; numerous narrow, spatulate, **unguiculate (like clasped hands), straight pedicellariae (2)** in the furrow margin and elsewhere. **Straight series of carinal plates (3)** with three or four series of meshes on each side.

Material Examined: Forty-three specimens in 13 lots from 538 – 1192 m depth between Cape Flattery and Port Louis, Graham Island.

Type Locality: Albatross 3425, Tres Marias Islands, Mexico (21° 19' N, 106° 24' W), 680 fms (1236 m), gray sand.

Previous Known Distribution: Western Mexico to Washington, 510 – 1240 m (Clark and Mah 2001); Tres Marias Islands to Vancouver Island, 507 – 1236 m (Lambert 1978b).

New Distribution: Western Mexico to Graham Island, BC, 507 – 1240 m.

Remarks: This extends the northern limit from the northern tip of Vancouver Island to Graham Island.

Other References: Fisher (1928).

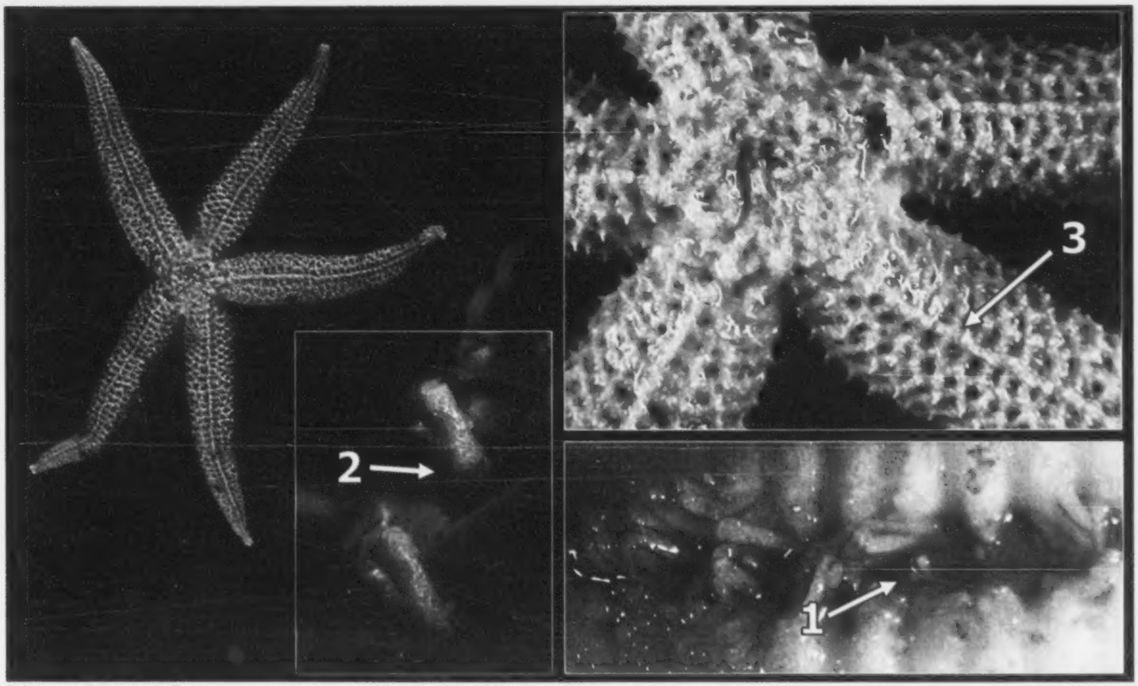
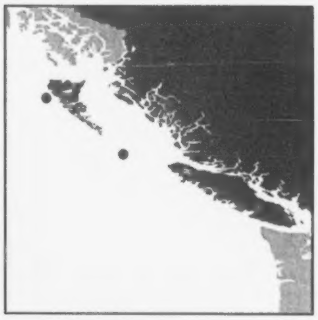


Figure 94. *Ampheraster marianus* (Ludwig, 1905)



Anteliaster coscinactis Fisher, 1923

Diagnostic Characters: Inferomarginal spines not conspicuously larger than superomarginals; adambulacral spines are the longest and most conspicuous on the oral side; tube feet in two rows. Crossed pedicellariae with numerous terminal teeth; papulae on aboral side of arms. Large hand-shaped unguiculate straight pedicellariae. Spinelets with numerous terminal thornlets.

Material Examined: Eight specimens in two lots from 837 – 950 m between Queen Charlotte Sound and Rennel Sound, Haida Gwaii.

Type Locality: Albatross 4427, off Santa Cruz Island, California (34° 2' N, 119° 31' W), 447-510 fms (818 – 933 m), black mud, rock. (Fisher 1928)

Previous Known Distribution: Southern California, 820 – 930 m (Clark and Mah 2001); northern Oregon, 896 – 914 (Alton 1966b).

New Distribution: From Santa Cruz Island to Rennel Sound, Haida Gwaii, 817 – 950 m.

Remarks: This study extends the geographic range from Oregon to Rennel Sound, Haida Gwaii and the maximum depth to 950 m.

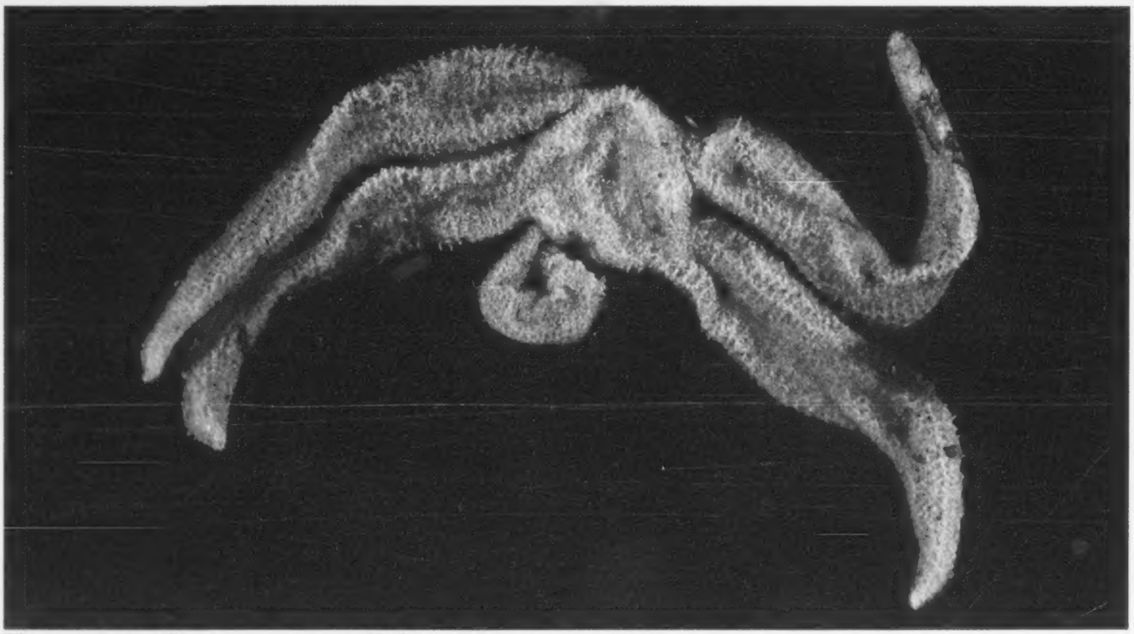
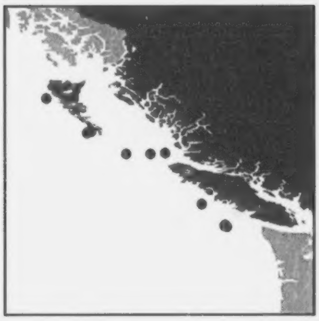


Figure 95. *Anteliaster coscinactis* Fisher, 1923



Pedicellaster magister Fisher, 1923

Diagnostic Characters: Five slender, flexible rays, **slightly inflated above the base (1)**; type has rays 85 mm long. On oral side a conspicuous series of **transverse four-lobed plates (2)** which increase in number toward the middle third of the ray then decrease slowly in the final third. **Slender-jawed major crossed pedicellariae (3)**.

Material Examined: Fifteen specimens in 12 lots from 200 – 1776 m between Juan de Fuca Strait and Rennel Sound, Haida Gwaii.

Type Locality: Albatross 4792, off Cape Monati, Bering Island (54° 36; 15" N, 166° 57' 15" E), 72 fms (132 m), pebbles (Fisher 1928)

Known Distribution: Southern Bering Sea from Commander Islands to Unimak Island south to Prince of Wales Island, Alaska, 77 – 221 m (42 – 121 fathoms) (Fisher 1928); off BC between Juan de Fuca Strait and Cape St. James; 223 – 1032 m (Lambert 1978a).

Remarks: This study extends the maximum depth from 1032 to 1776 m.

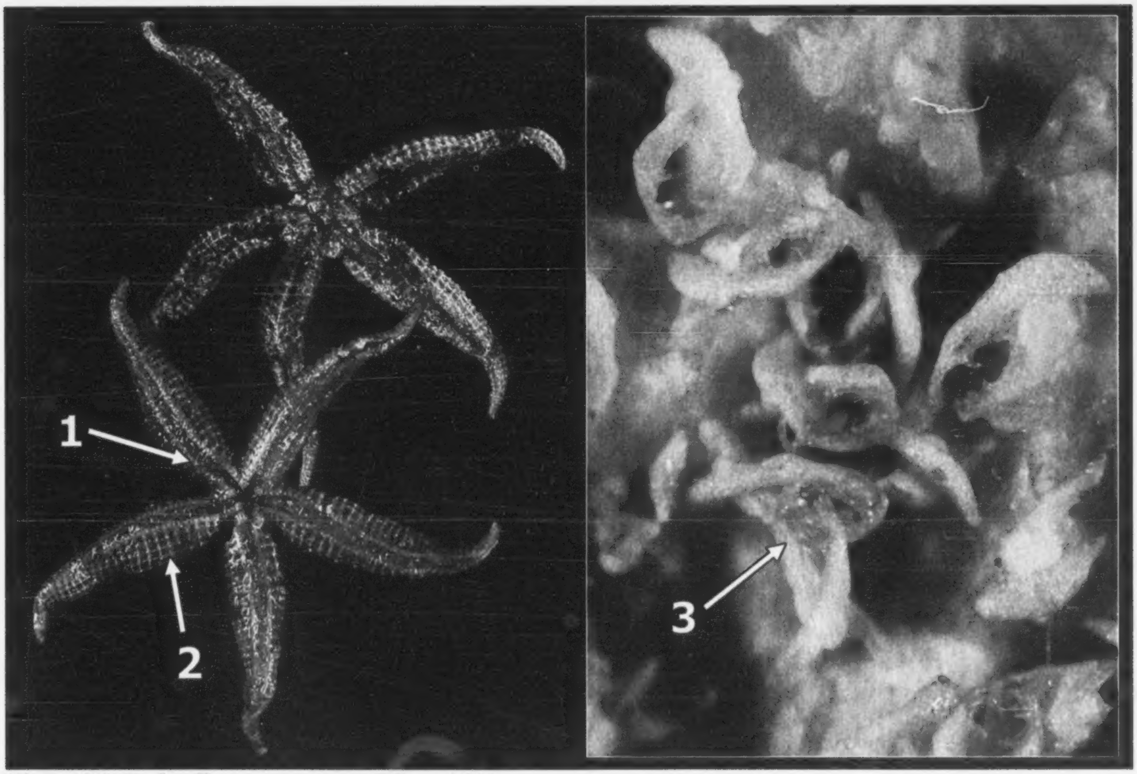
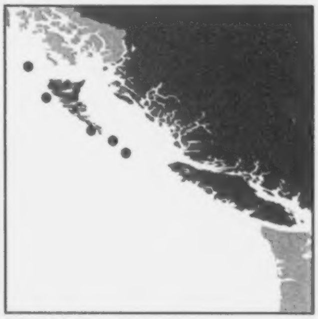


Figure 96. *Pedicellaster magister* Fisher, 1923.



Tarsaster alaskanus Fisher, 1928

Diagnostic Characters: Five rays tapering gradually from a swollen base, marked off from disk by a crease. **Carinal plates forming slight convex ridge (1)**; adambulacral plates with 2 spines (diplacanthid) except 3 near mouth. **Tube feet in four rows (2)** reduced to two distally.

Material Examined: Ten specimens in five lots from 229 – 1087 m between Queen Charlotte Sound and Dixon Entrance.

Type Locality: Albatross 4230, off Indian Point, near Naha Bay, Behm Canal, Alaska (55° 36' N, 131° 41' W), 108-240 fms (198 – 439 m), rocky. (Ahearn 1995)

Known Distribution: SE Alaska (Fisher 1928); Oregon to Skidegate Channel, Haida Gwaii, 198 – 2100 m (Lambert 1978b).

Remarks: Within known geographic range.

Other References: Alton (1966b).

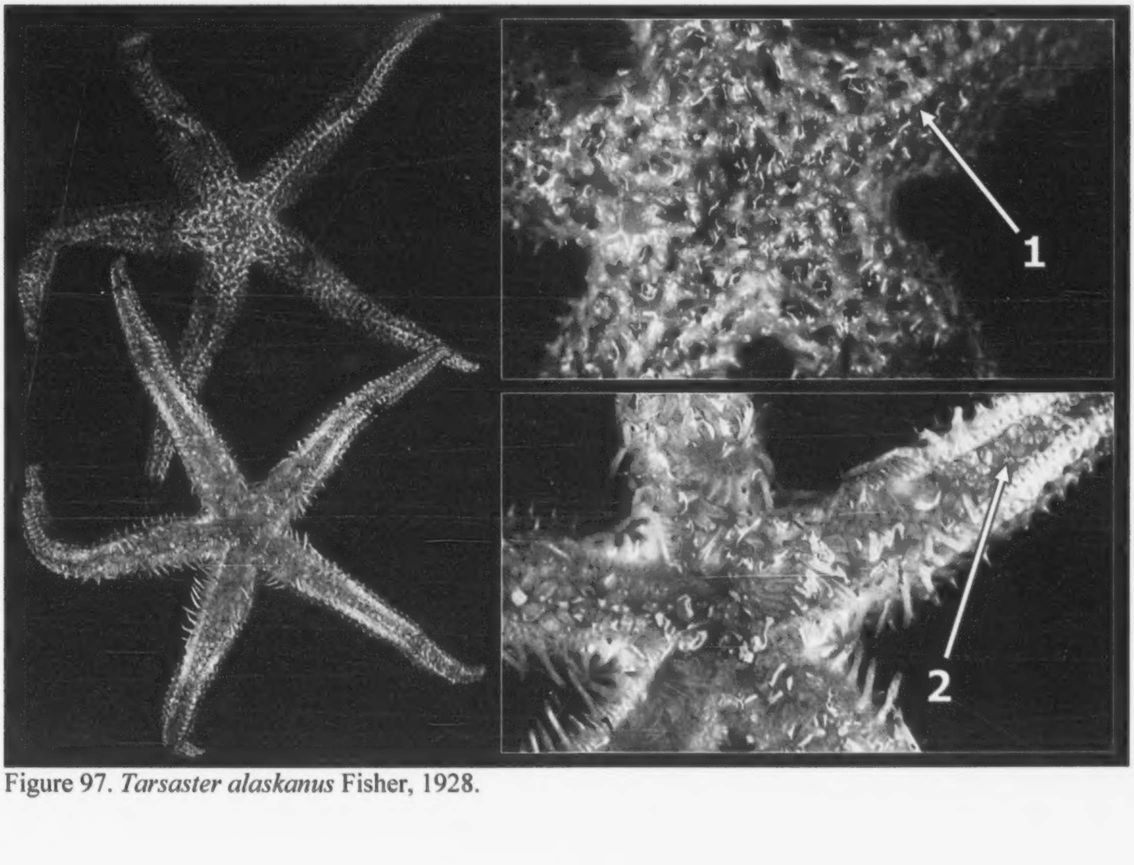
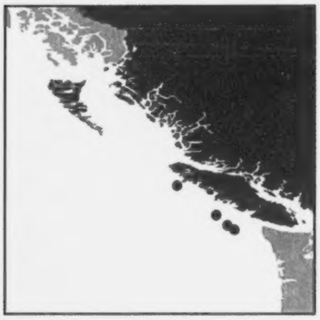


Figure 97. *Tarsaster alaskanus* Fisher, 1928.



Family Labidiasteridae

Rathbunaster californicus **Fisher, 1906**

Diagnostic Characters: Usually 17 rays but varies from 12 – 20; length of ray up to 155 mm. Disk flat; rays long and slender, **constricted adjacent to disk (1)**, inflated proximally. Aboral skin thin and membranous with small circular plates bearing a slender spine wreathed by pedicellariae on a retractile sheath. Superomarginal plates above alternate inferomarginals; **one long adambulacral spine (2)**; **numerous vermiform papulae on disk (3)** in groups of 2 – 15.

Material Examined: At least six specimens in four lots from 285 – 512 m between mouth of Juan de Fuca Strait and northern Vancouver Island, off Brooks Peninsula.

Type Locality: Albatross 2925, off San Diego, California (32° 32' 30" N, 117° 24' 30" W), 339 fms (620 m), mud.

Previous Known Distribution: Off California from San Diego to Point Arena, 207 – 369 fathoms (Fisher 1928); Oregon, Washington, southern Vancouver Island, 134 – 675 m (Lambert 1978b).

New Distribution: San Diego, California to northern Vancouver Island off Kyuquot Sound, 134 – 675 m.

Remarks: This study extends the northern range slightly to 49° 56.5'N from 48° 47'N off Kyuquot Sound.

Other References: Alton (1966b), Lissner and Hart (1996), Mah (1997).

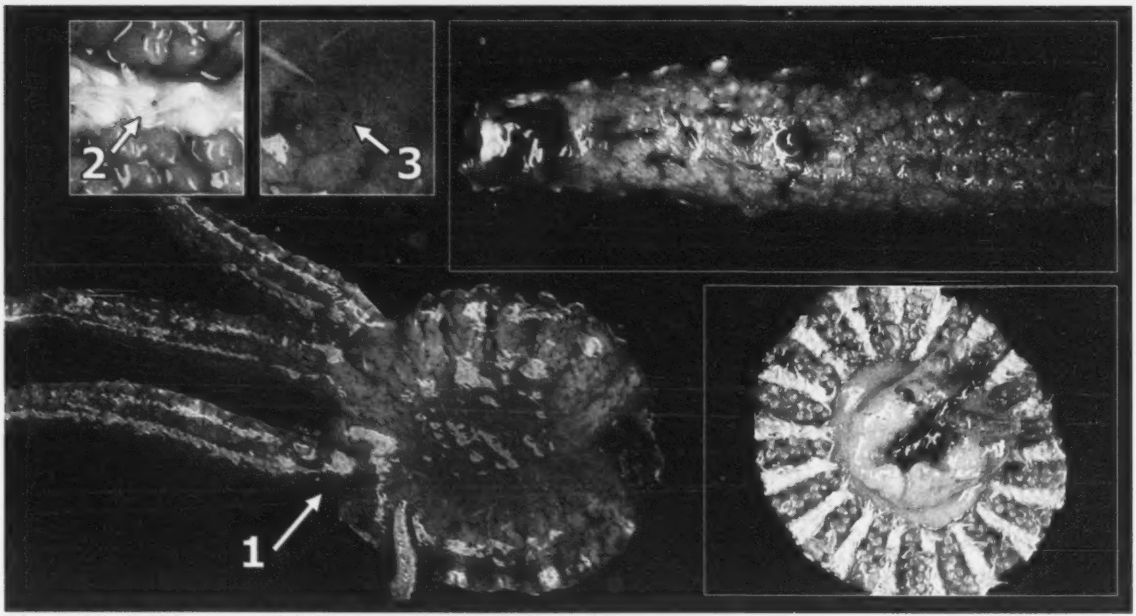
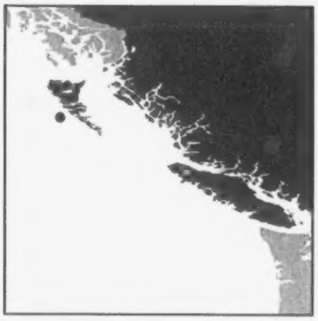


Figure 98. *Rathbunaster californicus* Fisher, 1906



Order Brisingida

Family Brisingidae (Deep-sea Suspension feeders)

Brisinga synaptoma **(Fisher, 1917)**

Synonyms: *Craterobrisinga synaptoma* Fisher

Diagnostic Characters: Twelve to fifteen rays up to 245 mm; crossed by 35 – 40 well-spaced spiny ridges (costae); disk with prominent solitary spinelets, except more on primary radial plates; no disk pedicellariae; adambulacral plates short and broad with usually two furrow spinelets and two subambulacral spines in a transverse series. The first 10 or 12 outer subambulacral spines have a circular, enlarged, sharply truncate tip.

Material Examined: None collected in this study.

Type Locality: Albatross 3342, off Tasu Sound, Haida Gwaii (52° 39' 30" N, 132° 38' W); 1588 fms (2904 m), gray ooze and coarse sand (Fisher 1928).

Known Distribution: BC to Mendocino Ridge, California, 1353 – 3176 m (Mah 1997).

Family Freyellidae

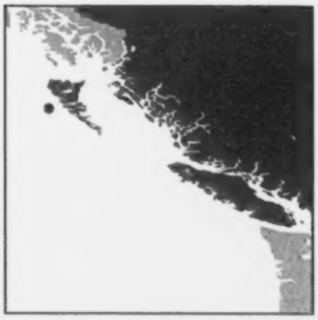
Astrocles actinodetus **Fisher, 1917**

Diagnostic Characters: Eleven rays, with fairly large disk covered with circular plates bearing one to three spines; genital region of ray 1/6 total length crossed by 25 – 27 transverse arches covered by minute pedicellariae and small spinelets; intervals between arches without plates or pedicellariae. Slender, delicate lateral spine opposite alternate adambulacrals; adambulacral spines: one aboral furrow spinelet with broad triangular tip and one subambulacral spine (proximal spines with enlarged bifid tip).

Material Examined: None collected in this study.

Type Locality: Albatross 2859, off Prince of Wales Island, SE Alaska (55° 20' N, 136° 20' W), 1569 fms (2869 m), gray ooze (Fisher 1928).

Known Distribution: Kamchatka opposite Avacha Bay, Russia, to BC and Oregon; 2870 – 4200 m (Mah 1997).



Freyella microplax (Fisher, 1917)

Synonyms: *Freyellidea microplax* Fisher

Diagnostic Characters: Twelve rays (170+ mm), not deciduous, with a short swollen genital region, no transverse ridges. **Disk closely covered with short spinelets (1)**, four or five to a plate. Short lateral spine opposite alternate adambulacral plates; one aboral furrow spinelet and one subambulacral spine (2) with enlarged truncate tip (at base of ray). First adambulacral plates of adjacent rays not fused, outer end of mouth plates between.

Material Examined: Two specimens in one lot from 1986 – 2105 m off Skidegate Channel.

Type Locality: Albatross 3342, off Tasu Sound, Haida Gwaii (52° 39' 30" N, 132° 38' W), 1588 fms (2904 m), gray ooze and coarse sand (Fisher 1928).

Previous Known Distribution: BC to Central California, 1722 – 3176 m (Mah 1997).

New Distribution: Central California to central Haida Gwaii, BC, 1722 – 3176 m.

Remarks: Range extended slightly farther north than Tasu Sound to Skidegate Channel.

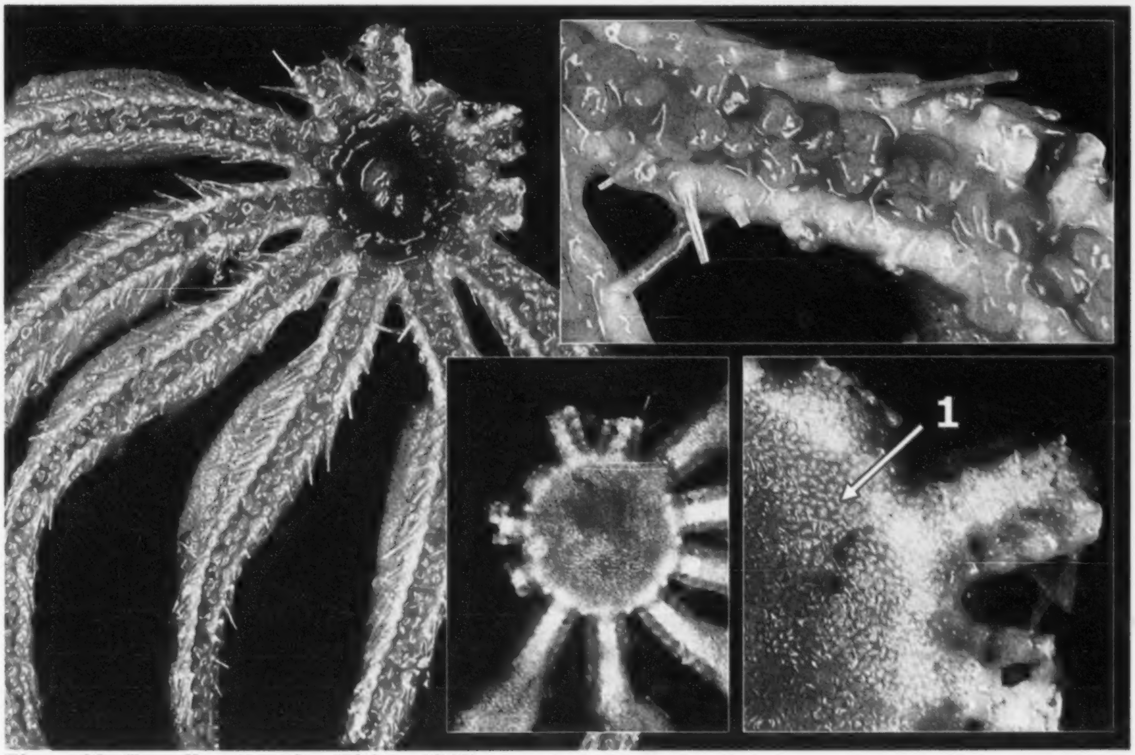
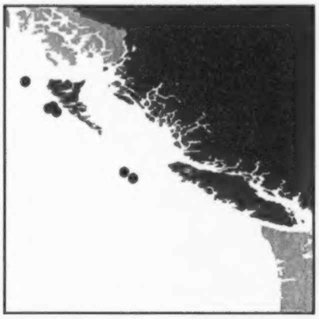


Figure 99. *Freyella microplax* (Fisher, 1917)



Freyellaster fecundus (Fisher, 1905)

Synonyms: *Freyella fecunda* Fisher

Diagnostic Characters: Thirteen rays (330 mm); genital region about ½ length of ray but not conspicuously inflated. Evenly distributed aboral plates thin, with one to three small prickles. The first twelve or fifteen subambulacral spines with a truncate flaring tip; proximal adambulacrals with three aboral spinelets in a transverse series.

Material Examined: At least 13 specimens in six lots from 1100 – 2105 m between northern Vancouver Island and Langara Island.

Type Locality: Albatross 4530, off Point Pinos, Monterey Bay, California (36° 38' N, 121° 55' W), 755-958 fms (1381-1752 m), gray mud (Ahearn 1995, Fisher 1928).

Previous Known Distribution: Okhotsk Sea (Japan), BC to central California, (Point Pinos, Monterey Bay), 880 – 2124 m (Mah 1997).

Remarks: This species is very fragile and is usually collected in many pieces, hence the uncertain number of specimens.

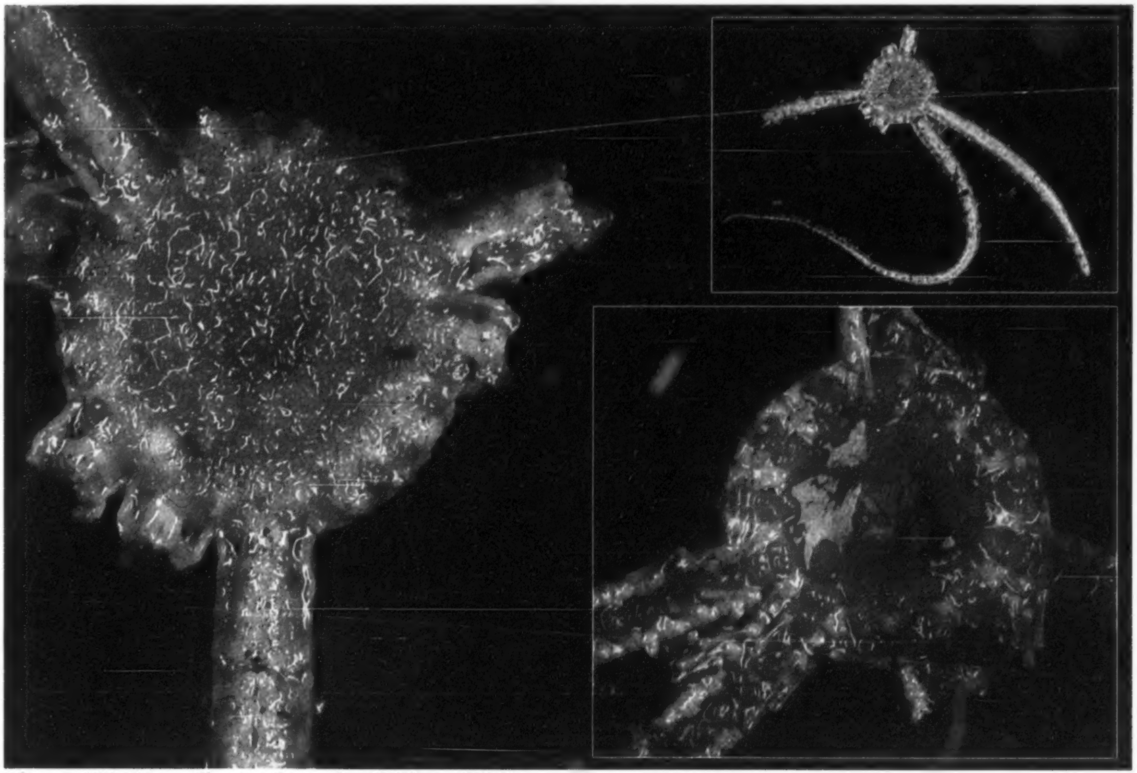
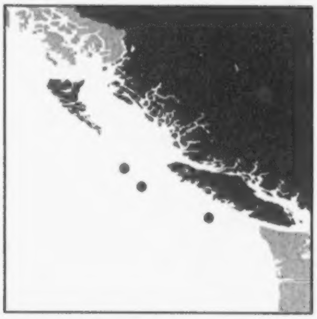


Figure 100. *Freyellaster fecundus* (Fisher, 1905)



Family Hymenodiscididae (after Mah 1997)

***Astrolirus panamensis* (Ludwig, 1905)**

Synonyms: *Brisinga panamensis* Ludwig

Diagnostic Characters: Eight or nine arms. **Costae on aboral arm surface (1)** with a band of pedicellariae but also perforated plates of irregular shape in the skin. Interbrachial marginal plates between basal ambulacrals.

Material Examined: Five specimens in three lots from 1353 – 2150 m between Juan de Fuca Strait and Queen Charlotte Sound, off northern Vancouver Island.

Type Locality: Albatross 3362, off Costa Rica (5° 56' N 85° 10' 30"), 1175 fms (2149 m), green mud, stones and rock. (Ahearn 1995)

Previous Known Distribution: East Pacific – Cocos Islands, Malpelo Island, the Galapagos, Gulf of California, and Gulf of Panama to Oregon, 1820 – 2418 m (Mah 1997).

New Distribution: Eastern Pacific to northern tip of Vancouver Island, 1353 – 2418 m.

Remarks: This study extends the geographic range north to Queen Charlotte Sound from Oregon.

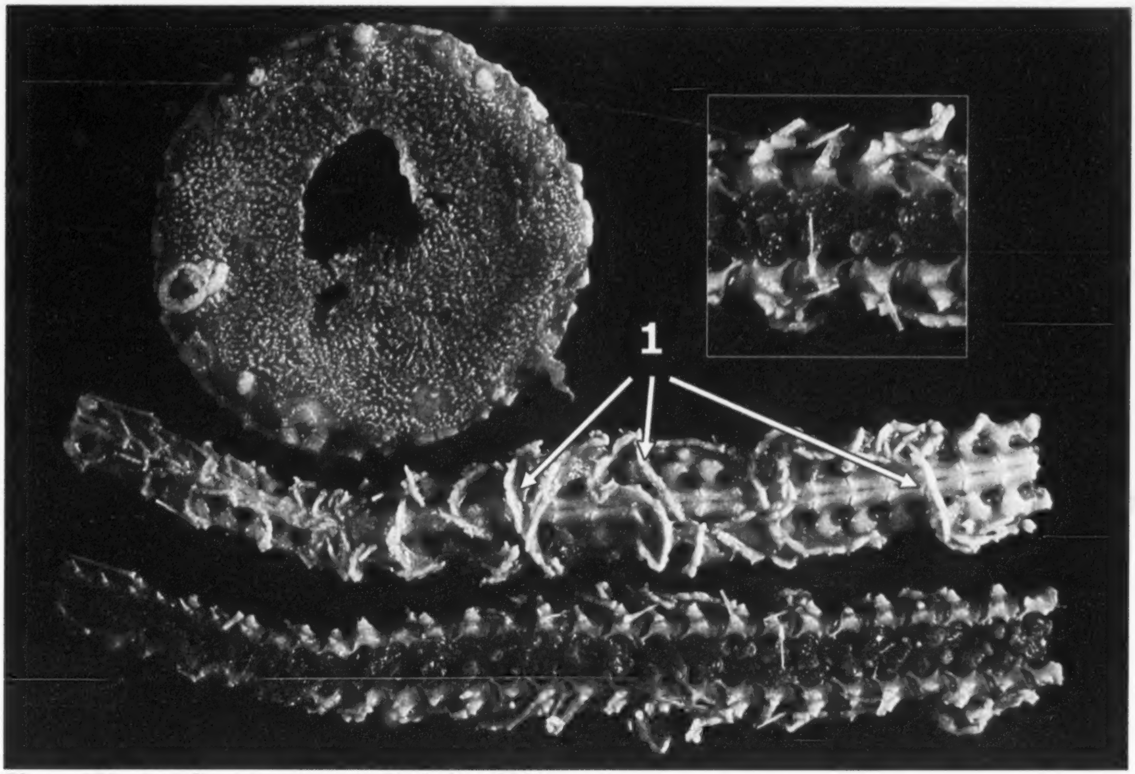
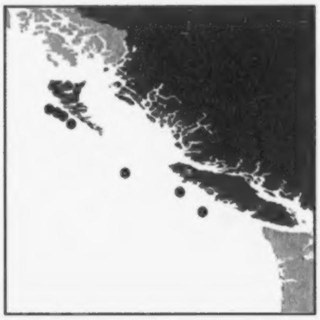


Figure 101. *Astrolirus panamensis* (Ludwig, 1905).



Hymenodiscus pannychia (Fisher, 1928)

Synonyms: *Brisingella pannychia* Fisher

Diagnostic Characters: Ten arms. Spinelets on disk solitary but occasionally two or three to a plate, delicate and sharp but encased in membrane. Longest fragment of arm on type with 19 **costae (1)**. Slender intercostal band of crossed pedicellariae but no perforated plates in skin. Costae correspond to alternate adambulacrals and possess a spine at base of each costa. 1 short furrow spine,1 adoral spinelet and 1 slender subambulacral. Syzygy (tight joint) between 1st and 2nd adambulacral.

Material Examined: Eighteen specimens in seven lots from 1450 – 2300 m between central Vancouver Island and Skidegate Channel, Haida Gwaii.

Type Locality: Albatross 4767, Bowers Bank, Bering Sea (54° 12' N, 179° 7' 30" E), 771 fms (1410 m), green mud.

Previous Known Distribution: Alaska – Bowers Bank, Bering Sea; 1542 m (Clark and Mah 2001).

New Distribution: Bering Sea to central Vancouver Island, BC, 1410 – 2300 m.

Remarks: This study extends the known range south to central Vancouver Island, BC.

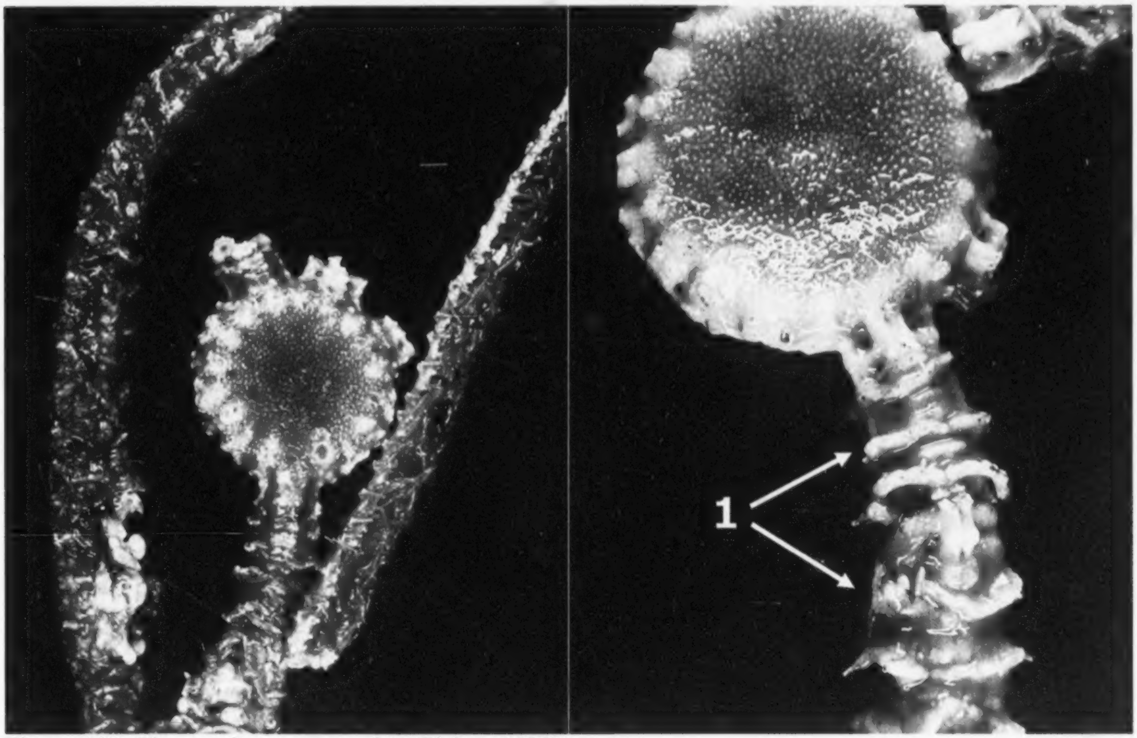
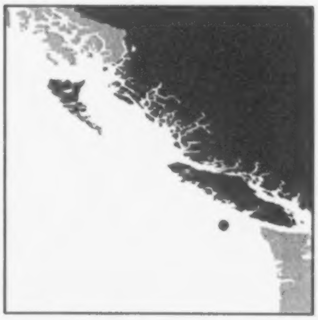


Figure 102. *Hymenodiscus pannychia* (Fisher, 1928)



Hymenodiscus pusilla (Fisher, 1917)

Synonyms: *Brisingella pusilla* Fisher

Diagnostic Characters: Ten arms R=165+; thin disk, slender flexible rays; 25 – 30 costae at least ¾ the length of the ray; on the disk relatively few small plates bearing one or two small spinelets. Second ambulacral ossicle a bit more than half the length of the first. Furrow spinelets confined to the first 3 – 14 adambulacral plates.

Material Examined: Two specimens in one lot from 725 – 760 m off mouth of Juan de Fuca Strait.

Type Locality: Albatross 4427, off Point San Pedro, Santa Cruz Island, California (34° 2' N, 119° 31' W); 447 – 510 fms (817 – 933 m), black mud and rock (Fisher 1928).

Previous Known Distribution: Off southern California, San Diego to Santa Cruz; 602 – 2118 m (Mah 1997).

New Distribution: San Diego to Juan de Fuca Strait; 602 – 2118 m.

Remarks: Mah (1997) placed *B. pusilla* into *Hymenodiscus*.

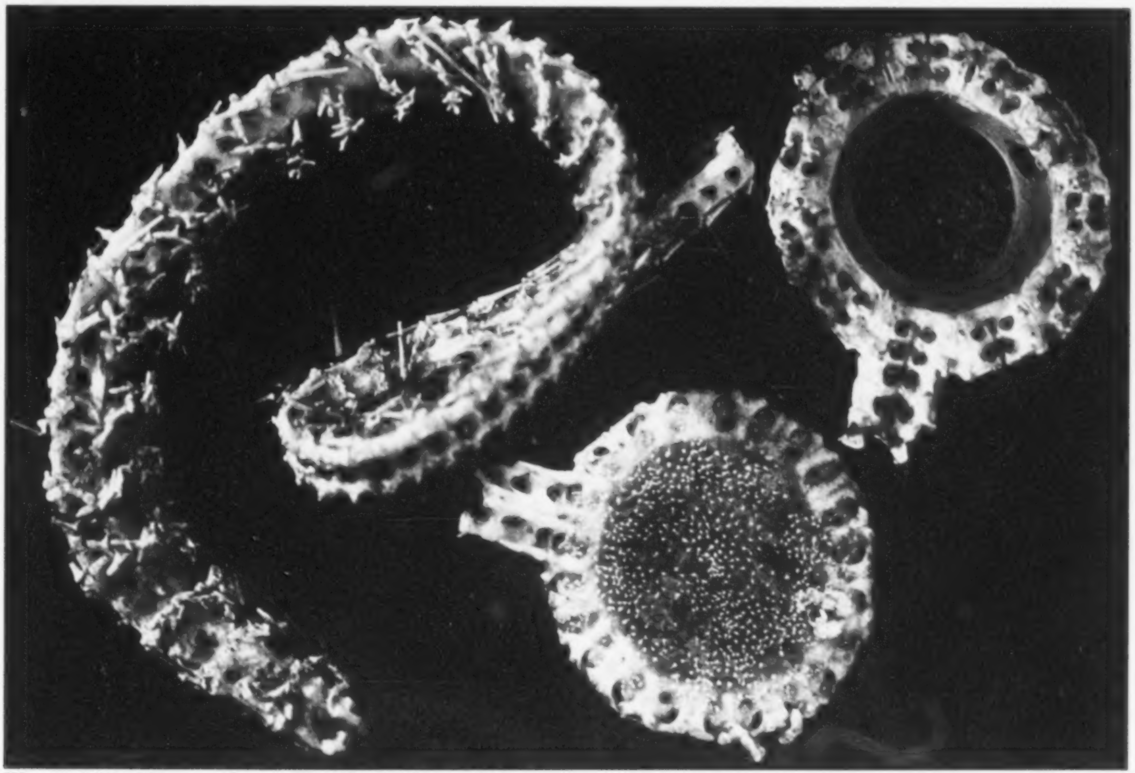


Figure 103. *Hymenodiscus pusilla* (Fisher, 1917)

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Appendix 1: Glossary of Terms

aboral	The opposite side of an echinoderm from where the mouth is situated, usually uppermost, except for crinoids.
aboral cup	See **calyx**.
aboral plates	**Calcareous plates** on the **aboral** side of the body.
actinal	See **oral**.
actinal intermediate plates	Plates on the **oral** side of a sea star arm situated between the adambulacrals on the edge of the furrow and the first row of inferomarginal plates on the side of the arm.
actinal system	Plates around the mouth (**oral**) area of an echinoid.
actinolateral membrane	A membrane supported by long spines that originate on the **distal** ends of the adambulacrals and extend out towards the edge of the arm.
actinolateral plates, actinolateral series	See **actinal intermediates.**
actinolateral spines	Spines that support the **actinolateral membrane**.
adambulacrals, adambulacral plates	**Calcareous plates** that form the sides of the **ambulacral furrow**.
adoral shield.	One of two plates in ophiuroids adjacent to an **oral** shield on the side closest to the mouth.
adradial series	A row of plates on the **oral** surface of an asteroid running parallel to the **adambulacrals**.
ambitus	The point of greatest circumference of an echinoid **test**.
ambulacral groove	A longitudinal depression on the oral side of a sea star arm bearing rows of tube feet.
ambulacral furrow	See **ambulacral groove**.
ambulacral podia	Tube feet (podia) following an **ambulacral radius** as opposed to respiratory podia
ambulacrum	See **ambulacral groove**.
apex of jaw	The tip of a triangular plate jutting into the centre of the mouth region of ophiuiroids and asteroids.
arm comb	A single or series of **spinelets**, typically in a comb-like row, at the edge of the disk just above each arm of ophiuroids.
basal	At the base of a structure.
bifid	Having two points or branches at the end of a structure.
bivalve pedicellaria	See **pedicellaria.**
bivial ambulacra	Usually the underside or posterior of an echinoid made up of two rows of podial plates (**ambulacra**) and a set of **interambulacral plates.**
brachials	The segments that make up the arms of crinoids.
calcareous	Made of some form of calcium carbonate.
calcareous deposits	Usually refers to microscopic calcareous **ossicles** in the skin of sea cucumbers or other echinoderm.
calyx	The main cup-like body of a stalked crinoid from which the arms and stalk emerge, made up of the **radial** and **basal** plates of a crinoid.
carinals	A row of plates running down the middle of the **aboral** surface of a sea star arm, usually bearing obvious spines.
carinate	Bearing a central ridge.
cirri	Unbranched, segmented appendages at the base of the **calyx** that a crinoid uses to cling to the substrate.
clavate	Club-shaped, broader at the tip than the shaft.
centrodorsal, centrodorsal ossicle	The central **ossicle** at the base of un-stalked crinoids (comatulids) bearing the **cirri**.
columnals	**Calcareous** segments that make up the supporting column of a stalked crinoid.
costae	**Calcareous**, transverse ridges on the arms of Brisingid asteroids, such as Hymenodiscus.
costal ridges	See **costae.**
crenulate	Wrinkled or ridged.

Glossary (Cont.)

cribriform organs	Specialized grooves, between **marginal plates**, lined with cilia that create a current to move food particles from the **aboral** surface to the mouth.
crossed pedicellaria	See **pedicellaria**
deciduous	Able to voluntarily detach a limb from the body. Often used as an escape tactic.
dermal branchiae	See **papulae**.
digitate	A type of short stubby tentacle with a few side branches.
diplacanthid spines	Refers to pairs of spines on a single **adambulacral plate**.
disjunct	Not united or joined; the geographic distribution of an organism with a major break in its known distribution.
distal	In a direction away from the centre of the disk.
dorsal papillae	In sea cucumbers, soft, elongate structures of various sizes emanating from the upper side of the body.
dorsum	The **dorsal** or top side of an animal.
epiproctal cone	A nipple-like extension bearing the anus, on the the **aboral** side of some mud-dwelling sea stars, such as Eremicaster.
fasciolar grooves	Furrows between marginal plates of asteroids bearing cilia for creating respiratory or feeding currents; usually protected by overhanging spines.
furrow	See **ambulacrum.**
furrow spines	Spines located on the inner edge of the **adambulacral plates**, overhanging or projecting into the **ambulacral furrow**.
genital pores	Pores through which eggs and sperm are shed to the exterior.
globiferous pedicellaria	See **pedicellaria.**
globigerina	A microscopic marine protozoa with a **calcareous** shell (foraminifera). Globigerina ooze is mud created from the shells of these dead organisms.
granules	Tiny grain-like **calcareous** pieces embedded in the skin.
holotype	A single specimen on which the original description of a species is based.
imbricate	Overlapping like shingles; used to describe certain asteroid skeletons.
inferior marginals	See **inferomarginals.**
inferomarginals, inferomarginal plates	Plates forming the lower side of the arm between the oral and **aboral plates**; also called **infra**, **inferior** or **lower marginals**.
infradental papillae	In amphiurid ophiuroids, a pair of block-like plates at the ventral tip of the jaw.
inframarginals	See **inferomarginals.**
interbrachial marginal plates	**Marginal plates** that come together at the crux of two arms between adjacent rows of **adambulacrals** in Hymenodiscidid asteroids.
intercostal	The space between **costal ridges** of Brisingids.
intermarginals	Row or rows of plates between the **infero** and **superomarginal** plates of a sea star, usually at the base of the arm near the central disk.
internal buttress	In some Zoroasteridae a solid plate joins the **ambulacral plates** near the mouth to the outer wall of the arm. This requires dissection (See fig. 2D in Mah 2007).
interradial, interradii	Referring to a pie-shaped area between the main arms of a sea star or brittle star.
knotty	Resembling a series of knots on a piece of string.
lectotype	If an author did not designate a **holotype** in the original description, a single specimen (the **lectotype**) may be selected from a series of specimens collected at the type locality, to act as the **holotype**.
lower marginals	See **inferomarginals.**
madreporite	A modified **inter-radial plate** on the **aboral** side of the disk pierced by numerous small pores that connect with the water vascular system.
marginals, marginal plates	Series of skeletal plates along the side of the arm between aboral and oral series; the term includes **superomarginals, intermarginals** and **inferomarginals**.

Glossary (Cont.)

nidamental chamber	A space between the true **aboral** surface and a thin-skin or **supradorsal membrane** supported by the tips of the **pseudopaxillar spines** in the asteroid family Pterasteridae. In some species it acts as a brood chamber for developing embryos (from the Latin nidus, meaning nest).
odd interambulacrum	The area between two rows of **tube feet (ambulacra)** at the posterior of irregular sea urchins.
opercular	Rounded like an operculum, or gill flap, of a fish.
ophicephalous pedicellaria	See **pedicellaria.**
oral	The side of an echinoderm where the mouth is, usually facing the substrate, except for crinoids.
oral intermediate area	The **interradial** area on the **oral** side of a sea star.
oral papilla	One of a series of small **ossicles** along the edge of a jaw, or attached to an **oral** plate or an **adoral shield** of brittle stars.
oral shield	A large shield, or diamond-shaped, plate in each ventral **interradius distal** to the jaws.
oral spines	Spines on the mouth plates of asteroids.
ossicle	In echinoderms, refers to a single **calcareous** element of the skeleton, and most often refers to the isolated **calcareous** bodies in the skin of sea cucumbers.
osculum	A central pore in the **supradorsal membrane** of the Family Pterasteridae through which water is expelled from the **nidamental chamber**.
papilliform	In the shape of nipple-like extensions.
papulae	The gills of a sea star, thin-walled sacs that extend from the coelom to the outside, between the **calcareous** plates, that serve in respiration and waste removal. Most **papulae** have a simple tubular or conical shape, but some are branched.
papular area	A region on the body of an asteroid where the gills (**papulae**) penetrate the skeletal structure to the outside. May be spread all over the body or restricted to certain areas.
papularium, singular papularia	Well-defined round patches of **papulae** on the aboral surface of a sea star; typical of the Family Benthopectinidae.
paxillae, paxilla	The columnar or mushroomlike **aboral** plates of some sea stars. The expanded tops are covered with moveable **spinelets**.
pectinate pedicellaria	See **pedicellaria.**
pedicellaria, pedicellariae	A small jawlike structure that occurs in numbers on the outer surface of many sea stars and sea urchins. Ten kinds of **pedicellariae** are mentioned in this report: 1. **Bivalve** Two-jawed, shaped like a clam shell, as in the genus Hippasteria; 2. **Crossed** The two parts of the jaw cross each other like the blades of scissors; 3. **Globiferous** Three sharp, hook-like jaws covered with fleshy tissue on the end of a flexible stalk; 4. **Ophicephalous** Resembling a snake's head, three jaws that touch along their length; 5. **Pectinate** Made up of two sets of opposing teeth that interlock when closed; 6. **Spatulate** Straight with two jaws that are flat at their tips so that they resemble a spatula; 7. **Straight** Both parts of the jaw attach to the base and do not cross each other, so that it looks similar to forceps or tongs; 8. **Tridentate** Three jaw pieces that are bulbous at the bottom and separated from the others but coming together near the tips; 9. **Triphyllous** The jaws are short and as wide at the tip as near the base; 10. **Unguiculate** Two straight jaws with interlocking, finger-like extensions at the tips, looking like clasped hands.
peltate	A type of feeding tentacle in sea cucumbers resembling a mop.
periproct	A cluster of small plates embedded in a membrane around the anus of a sea urchin on the top side.
pinnule	A segmented appendage arising from the **brachial** segments of a crinoid.
podia, podium	See **tube feet.**

Glossary (Cont.)

polar area	The lower side (south pole) of the **centrodorsal ossicle** in a crinoid.
primary tubercles	The larger bumps on the plates of sea urchins bearing the base of the main spines.
prismatic spinelets	Short spines with three flat vertical sides like a prism.
proximal	In a direction toward the centre of the disk or a central axis
pseudopaxillae	Similar to **paxillae** except the spines on the top are fixed rather than moveable. Hard to tell with the naked eye.
radial	Refers to structures along the arms (the main radii) of a sea star or brittle star.
radial shield.	One of a pair of large plates near the edge of a brittle star disk where the arm attaches.
reticulate	Net-like or forming a mesh; used in description of asteroid skeletal plates.
rods	Elongate sea cucumber **ossicles**, smooth or with short side branches.
rugose	Rough; covered with small knobs or points.
scales	Small, thin calcareous plates overlapping like shingles.
segments	The calcareous pieces that make up the arms and stalks of crinoids.
serrate	Jagged, like the teeth of a saw blade.
spatulate	Elongate structure expanded and flattened at the tip, like a spatula.
spatulate pedicellaria	See **pedicellaria.**
spinelet	A small spine.
spiracula, spiraculae	Small contractile pores in the **supradorsal membrane** of the Family Pterasteridae.
squamiform	In the shape of a flat, pointed scale.
squamous granules	Flattened, slightly overlapping granules.
straight pedicellaria	See **pedicellaria.**
subambulacral spine	A spine on the edge of the **adambulacral plate**; not on the **oral** surface and not a **furrow spine.**
subanal rostrum	A narrow posterior projection of an urchin **test** below the anus.
subcylindrical	Not quite cylindrical, perhaps flattened slightly on one side.
submarginal	Situated just below the edge of the test, visible from below.
suboral spines	Spines situated on the **oral** surface of the mouth plates rather than on the edge (figure 12).
Superomarginals, superomarginal plates	A series of plates that form the upper lateral side or edge of the arm; also called **supra, superior** or **upper marginals**.
supradorsal membrane	A thin covering supported by the tips of the **pseudopaxillar** spines in Family Pterasteridae. Dermal branchiae (gills) are situated beneath this cover in the **nidamental** chamber.
synostoses, plural of synostosis	An effectively rigid articulation between columnals, **brachials** or **calyx ossicles** in a stalked crinoid with apposed **ossicle** faces flat or shallowly concave, and united by relatively few, short ligament fibers. It appears externally as a straight or gently curved suture.
syntype	Any of two or more specimens listed in a species description with no **holotype** designated. At a later date a single **lectotype** may be designated from among these **syntypes** to act in place of the **holotype**.
syzygy	Rigid **brachial** articulation in which alternating radiating ridges and depressions or grooves on the two joint faces appose each other rather than interlock; the external suture resembles a perforated line. They are widespread among comatulids but occur in stalked crinoids only in the arms of Guillecrinus and Vityazicrinus.
syzygal interval	The number of arm segments **(brachials)** between consecutive syzygial joints of a crinoid.
table ossicle	A skin **ossicle** in holothuroids shaped like an upside-down, small, round table. Consists of a perforated disk with a pointed spire in the centre.
tabulate plate	External plate of a seastar that bears a flat-topped projection bearing granules or **spinelets**.
tegmen	Mouth region of a stalked crinoid (sea lily) bearing the mouth, anal cone, and five **ambulacral grooves** (may be covered). Generally a flexible pavement of plates that is flat or elevated.

Glossary (Cont.)

tegminal	Refers to structures on the **tegmen** of a crinoid.
tentacle pore	An opening in the **oral** side of an ophiuroid arm segment through which a **tube foot** protrudes. The number of segments with pores and whether there are scales around the openings are important taxonomic characters.
tentacle scale	One or more **ossicles** at the edge of a **tentacle pore** along the arm of a brittle star. Typically much smaller than arm spines but some times not clearly different in form. **Ossicles** associated with the **oral tentacle pores** may, at least in part, be referred to as **oral papillae** in some groups.
terminal	At the end of a structure.
test	Refers to the spherical skeleton of a sea urchin made up of many small plates bearing spines and **pedicellariae**.
transverse	At right angles to the main axis or radius of an arm.
tridentate pedicellaria	See **pedicellaria.**
triphyllous pedicellaria	See **pedicellaria.**
tumid	Swollen.
tube feet	Part of the water vascular system consisting of extendible hollow tubes bearing a sucker at one end and operated by hydraulic pressure. Also called **podia** (singular **podium**).
tuberculation, primary	Refers to the arrangement of tubercles or bumps on a sea urchin test that support the primary spines.
type locality	Location where the **holotype** was collected.
velum	In holothuroids refers to a fold of skin formed by the merging of several papillae.
keel	A raised ridge on the **oral** side of an ophiuroid arm running longitudinally down the centre.
unguiculate pedicellaria	See **pedicellaria.**
ventrolateral	Region of a sea cucumber body between the side and the part resting on the substrate.
ventrum	The ventral or lower side of the body.
vermiform	Wormlike.
verrucose	Irregular raised ridges on a surface, like vericose veins.